MAY, 1941

THE Petroleum Engineer

VOL. XII—NO. 8

THE PETROLEUM ENGINEER PUBLISHING CO. . . . Phone: Central-4571 . . . Seventh Floor Allen Building . . . DALLAS, TEXAS

Clarence Morris, President, 1929-40

A Magazine of Methods for Operating Men

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CIRCULATION

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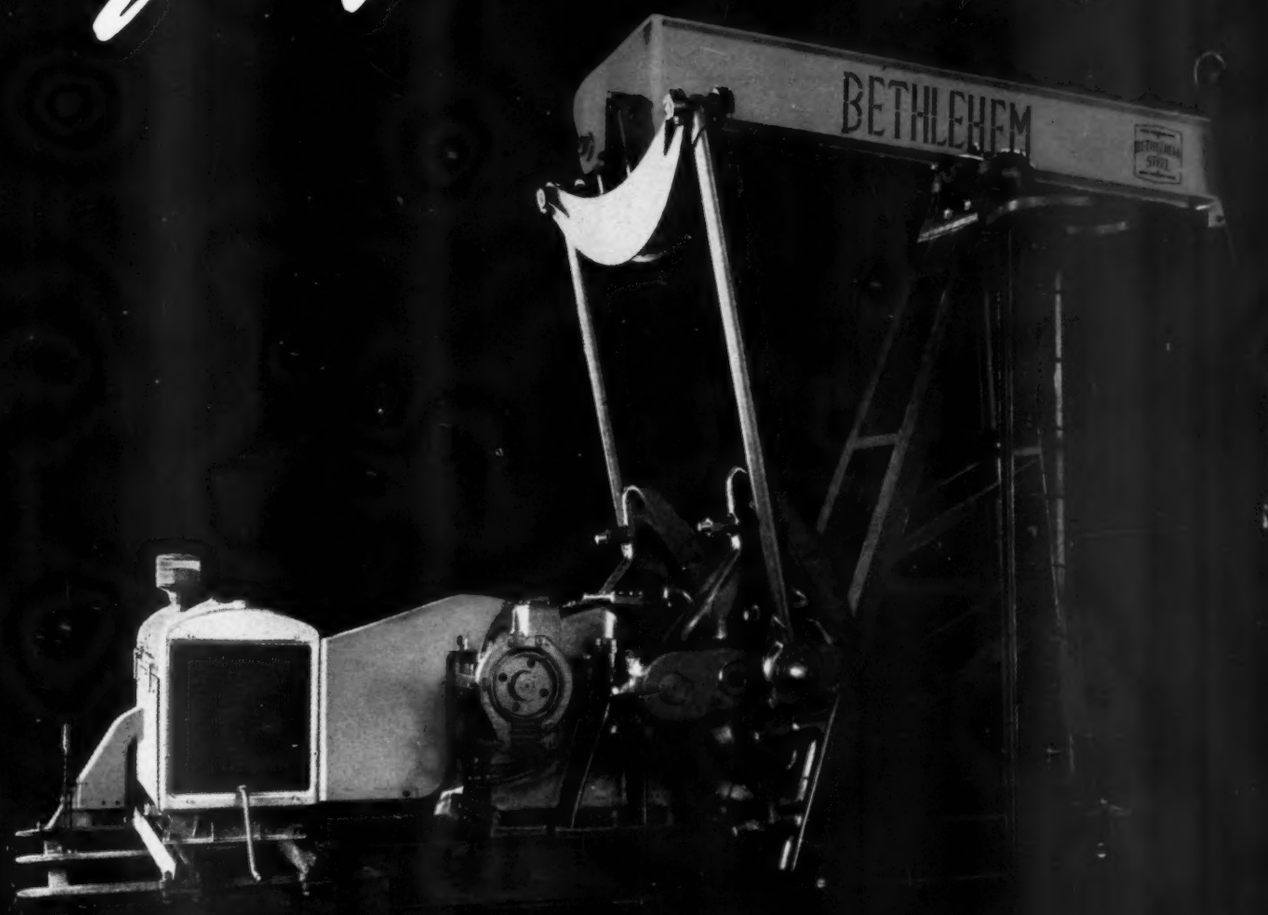
You get extra safety



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The Course of Oil

by K. C. SCLATER

Special Metals and Alloys

Curtailment in the use of special metals and alloys is a matter that affects manufacturers in particular and the oil industry in general. It may mean changing the designs of certain equipment should substitutes have to be used. Already some manufacturers have foreseen this exigency and have made or are making plans to meet it.

According to A. G. Zima, general chairman of the Western Metal Congress to meet in Los Angeles, May 19 to 23, radical changes in alloys for petroleum machinery and production tools may be expected soon. Field and refinery machinery soon will be fabricated from a new series of alloys.

Technical engineers and metallurgists from all parts of the country will meet at this Congress to discuss application of the steels to be substituted. The importance of this subject at the present time is obvious, for "restrictions caused by war conditions virtually have eliminated importation of chromium, manganese, mercury, tin, tungsten, and antimony. Other shortages exist.

"Metallurgists have learned through research how to fabricate fine machine parts using less of the alloying materials. In most instances the substituted alloy renders a service equal to or better than the one it replaces."

Such a discussion of metals and alloys is most timely and should be productive of much valuable technical information for the users of petroleum equipment and machinery.

Gratified with Progress

Members of the Cole Committee admittedly are satisfied that the oil industry is capable of meeting any demands that may be made upon it in the present national emergency.

"The committee recently completed a survey of several of the oil fields in the States of Louisiana, Arkansas, and Texas. We were gratified by the progress that has been made in the conservation of our oil reserves. State authorities and the oil industry have coöperated with Federal authorities in producing this highly beneficial result. Furthermore, we were amazed at the progress that has been made in the last few years in obtaining finer and better grades of gasoline and larger quantities per barrel of crude oil than heretofore. What is true of this one product, taken from crude oil, is equally true of the numerous and varied products originating from petroleum. The advancement that has been made in all branches of the oil industry has been so great that it is almost unbelievable. Suffice it to say that our observation of what the oil industry is doing, and is prepared to do in behalf of national defense gives assurance and courage to all who are interested in our national security and defense. The oil industry can be depended upon to do its patriotic part in fulfilling whatever task is laid upon it in the days that are ahead." Thus did Congressman Charles A. Wolverton, a member of the Cole Committee, express himself before the House of Representatives.

Chairman of the Committee, Wm. P. Cole, Jr., also had a word of praise for the progress and achievements of the industry, when he said that "It is pleasing to the committee to be able to report at this time, however, preliminary to our final report, that the petroleum industry is apparently in shape to meet almost any conceivable demand made upon it in these serious times. The conduct of certain States toward conservation of this most important natural resource is not what it should be, but we are hopeful before our final report is made that that situation will be materially improved."

There is every indication that the situation Chairman Cole refers to will have improved before the final report of his committee has been made.

Tankers and Pipe Lines

One bottleneck, the only serious one, that the oil industry may have to face is that of transportation. This applies particularly to the movement of crude oil and refined products from the Gulf Coast to the Atlantic seaboard. Normally, about ninety-seven percent is shipped by tanker and the remaining three percent by pipe line. Tankers are now being requisitioned by the Government for service elsewhere. Another contingency that has arisen in regard to tankers is their vulnerability to attack. The possibility of attack cannot now be considered a remote possibility. An expansion of pipe line facilities may therefore become imperative.

In normal times, it would not be justified on economic grounds to ship all the oil or even a major portion of it from the Gulf Coast to the Eastern seaboard by pipe line; but these are not normal times and at the moment it begins to appear as though some provision will have to be made for greater pipe-line transportation facilities to the Atlantic seaboard than are now available.

A new transportation arrangement has just been worked out to move crude from East Texas to the Atlantic seaboard by pipe line. Pipe line companies are following this development, for it may indicate the feasibility of transporting greater quantities of oil by pipe line. It is not believed, however, that for the present any much greater quantity of oil will be shipped by pipe line; pipe-line facilities are too inadequate for that.

Here is a problem that the transportation branch of the industry may be required to overcome urgently by some means should the requisitioning of tankers by the Government continue.

RE'S HOW... To Get Better Service from the Wire Rope You Use—

Assuming that you have bought and have had delivered to you the size, grade and construction of wire rope suitable for your work and equipment, the actual service you obtain from that rope—regardless of what the rope is capable of doing—will depend largely upon the following:

(1) *How the rope is handled from the time it is received until it is installed.*

(2) *The condition of the equipment on which the rope is to work, at time of installation.*

And here are some "Dos" and "Don'ts" that should prove valuable.

•1•

Right

Reels and coils of wire rope should not be dropped from car or truck when being unloaded.

Wrong

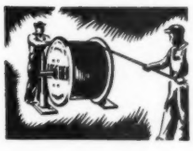
If iron bars are used to move reel, prying should be done under the reel flange and not against the rope.

If rope is not put into service when received, see that it is stored in a place protected from weather and free from acid fumes.

Use care when uncoiling or unreeling, so that the rope will not loop and form a kink.

•2•

Before a new rope is installed, make a thorough check-up of the equipment on which it is to work, to make sure



— that sheave grooves are of correct size and design.

— that sheave grooves are free from corrugations.

— that drum, sheaves and idlers are in line and properly lubricated so they will rotate freely.

— that there is no excessive fleet angle.

Unless you give your wire rope a fair chance, it will not give you the full service of which it is actually capable. In order to help all wire rope users obtain maximum efficiency from their wire rope, we publish a booklet "Practical Information on the Use and Care of Wire Rope," which covers many other conditions that deserve consideration. We would be glad to send a complimentary copy to any one interested.

A. LESCHEN & SONS ROPE CO.

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Highlights IN OILDOM

Conservation Bill Introduced in Illinois

An oil conservation bill has been introduced into the Illinois state senate that would create a three-member state commission with authority to regulate future drilling. The body would have no authority to limit production of existing wells, however. The commission would regulate future drilling by creation of drilling units. Governor Dwight Green, who is a proponent of the bill, said the proposed legislation would conserve the state's oil and natural gas resources.

Governor Green stated that "because Illinois' current oil production is below market demand, it is apparent there is no need of granting power to the state to restrict the production of Illinois oil."

The bill includes a "common purchaser" provision, which, Governor Green said "assures to the independent producer a ready market for his oil at posted market prices by compelling the larger units operating pipe lines to purchase and transport his oil."

Proposed Allowable Rule for Hawkins

A proposed rule designed to give small operators a better break in allowables in Hawkins field, Texas, is being studied by the Texas Railroad Commission. Its aim is to prevent any well on a 20-acre tract from obtaining more than twice as much as a well on a small tract.

This is the proposed rule:

To each non-marginal well, X bbl. of oil shall be allocated. In addition to X bbl., allocation of allowables shall be made at the rate of 5 percent of X bbl. for each acre in the unit on which the well is located. The sum of the allowable to non-marginal wells shall equal that part of the field allowable remaining after deducting the allowable for marginal wells. The value of X shall be determined by this formula:

$$X = T - M \div W + A/20$$

in which

X = basic proration factor
T = total field allowable
M = portion of field allowable alloted to marginal wells
W = total number of non-marginal wells
A = total acres allotted to non-marginal wells

The following table shows the relative allowables for various size tracts:

No. of acres in well unit	Relative allowables based on formula	Relative allowables based on unity for 20-acre well	No. of acres in well unit	Relative allowables based on formula	Relative allowables based on unity for 20-acre well
0.5	X+0.025X	0.5125	10.0	X+0.50 X	0.75
1.0	X+0.05 X	0.5250	20.0	X+1.00 X	1.00
2.0	X+0.10 X	0.5500	25.0	X+1.25 X	1.125
3.0	X+0.15 X	0.5750	30.0	X+1.50 X	1.250
4.0	X+0.20 X	0.6000	40.0	X+2.00 X	1.500
5.0	X+0.25 X	0.6250	50.0	X+2.50 X	1.750

Rejects Allocation Change

The Conservation Committee of California Oil Producers has voted to continue its customary method of allocating crude oil production, rejecting the recommended plan to increase the allocation to heavy oil, which was submitted recently by its allocation committee.

Joseph Jensen, chief petroleum engineer of the Tide Water Associated Oil Company, presented the case for the recommended plan, but withdrew his support when it was apparent that the committee was generally against it.

Opposition to any change in plan was voiced by representatives of San Joaquin Valley fields, who based their objections generally on the statement that there did not appear to them to be any great demand for heavy oil.

Louisiana Into Interstate Oil Compact

Governor Sam Jones made it known at the recent meeting of the Interstate Oil Compact Commission in New Orleans that Louisiana would join that body "for a trial period." The state legislature at its last session empowered him to bring the state into the Compact group when he deemed it advisable.

Illinois Crude Oil Price Advanced Again

Major oil companies have posted a 5-cent increase in the price of Illinois Basin crude oil. The new price is $1.27 per bbl. First to announce the advance were Ohio Oil Company and The Sohio Corporation. The Pure Oil Company, The Texas Company, Shell Oil Company, Inc., and the Gulf Refining Company followed.

Pennsylvania Oil Up 10 Cents

Prices of Pennsylvania crude oil have been advanced 10 cents per bbl., the second increase since the first of the year. The new quotations, announced by the Joseph Seep Purchasing Agency of the South Penn Oil Company, follow:

Bradford-Allegany, $2.40 per bbl.; southwest Pennsylvania, $2.05, and Eureka, $1.89.

Lift Proration in 13 Old Fields

The Oklahoma Corporation Commission on May 1 lifted proration in 13 old oil fields in the state. The pools are: Allen, Konawa, Maud, Olympic, Sacred Heart, Sasakwa, Sasakwa Townsite, South Cromwell, Keokuk Falls-Hunton, Meridian, Tecumseh (old), East Britton, and Doyle-Deese.

Pumping Wells Outnumber Flowing in Texas

Pumping wells are greatly in the majority among Texas oil wells, a survey just completed by the Texas Mid-Continent Oil and Gas Association shows.

The pumpers, many of them making only a barrel or two of oil a day, constitute almost 60 percent of all the oil wells in the state, the survey shows. Outside the East Texas field, the percentage is even higher, with 72 percent of all producing wells on the pump. In some areas of the state as high as 98 percent of all wells are pumpers.

In actual number, Texas pumping wells totaled 52,972 against 36,942 still flowing. Outside East Texas, pumpers numbered 45,836 compared with 17,844 flowing. Figures are as of January 1, 1940.

Out of the approximately million Texans who get their entire living from the petroleum industry, 125,000 depend solely upon pumping wells, the survey shows.

"While the average pumping well in Texas produces about 7 bbl. of oil daily, further analysis shows that nearly 24,000 stripper wells produce an average of only 3.9 bbl. per day," the association pointed out. "Some of these produce only half a barrel a day, but nevertheless are important to the small operator whose sole income comes from a few of them.

"These stripper wells are the backbone of the Texas oil industry as many communities and a majority of the people living in them depend upon such oil fields for their existence."

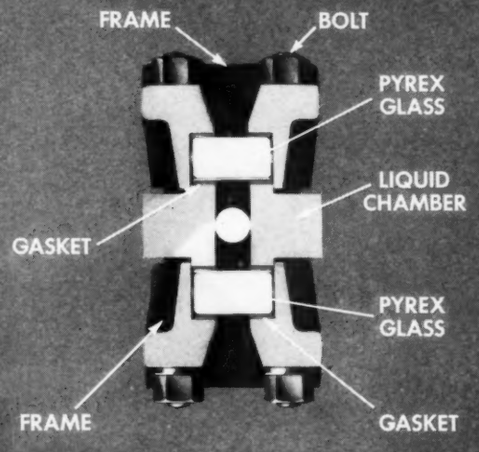
PENBERTHY

DROP FORGED STEEL

TRANSPARENT

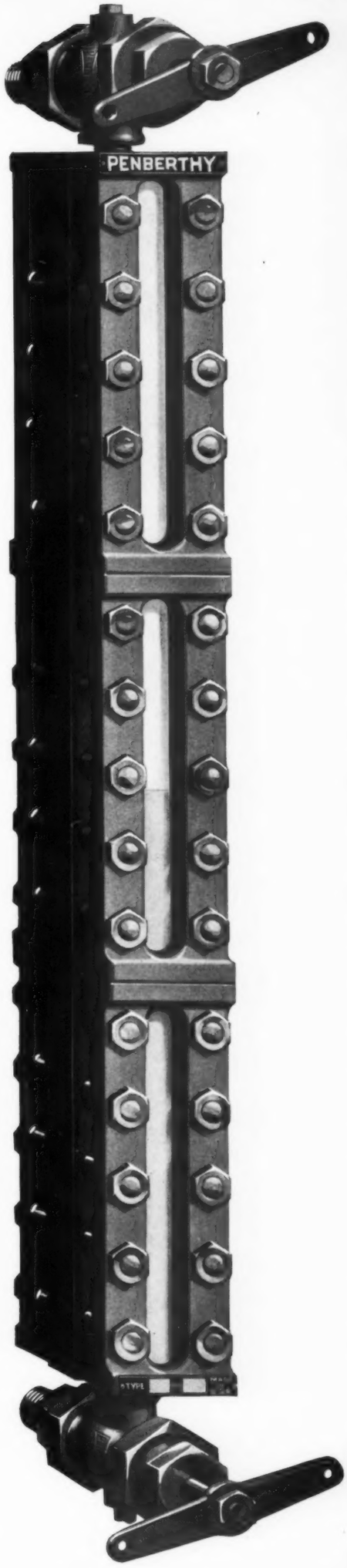
LIQUID LEVEL GAGES

To observe the color or density of liquids under high pressures and/or temperatures



Made of alloy temperature resisting steel. Liquid chamber for single or multiple section gage is made of a solid block of steel the full width of frame to assure perfect alignment and rigidity. Frame has an extra heavy beam at each end and glass chamber is accurately machined to the contour of the glass providing full metal backing for the gaskets. Pyrex glass has greater resistance to thermal shock and erosion.

These gages are available in any length and for various pressures and temperatures. We shall be glad to quote upon your requirements. Write for new Catalog 34-A.



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TRADE PENBERTHY PRODUCTS MARK

CANADIAN PLANT:
WINDSOR, ONTARIO

MAJOR *Refining* ACTIVITIES

Percent Refining Capacity Operated

Western Division, 74.2 Percent **Central Division, 83.3 Percent** **Eastern Division, 92.7 Percent**

CONSTRUCTION of a cycling plant at Oakwood, Dewey County, Oklahoma, by Magnolia Petroleum Company is nearer reality as a result of the granting to that company by the school land commissioner of leases on two 80-acre tracts of school land. These leases, entered into on a special contract, complete a block of 9600 acres that Magnolia proposes to develop as rapidly as possible.

One well already has been drilled to prove the area and several others are planned. Construction of the plant is expected to begin as soon as there is certainty of sufficient production of rich gas for processing. The school land leases were needed to round out the properties into a communitized lease for the operation.

If unitization plans now under way are completed successfully, Champlin and Bass, Inc., Dallas, Texas, will drill 8 to 10 wells and erect a cycling plant in the Sejita field, Duval County, Texas. The company has taken an assignment of condensate rights under several thousand acres covering the major part of the structure and is reported to be negotiating with several other operators for their leases to fill in the block. The plant would have a capacity of 50,000,000 cu. ft. per day or more, it is announced.

Shell Oil Company, Inc., has awarded a contract to the C. F. Braun Company for construction of an additional toluene plant at its Houston, Texas, refinery.

Dr. R. H. Waser, manager of the refinery, says the new plant will be a duplicate of the toluene plant that Shell put into operation at Houston last December. The combined capacity of the plants will be 4,000,000 gal. of toluene per year, from which about 40,000,000 lb. of TNT can be manufactured.

The new plant is expected to be completed by October 1.

H. B. Zachry, Larry O. Cox and Associates announce construction of a cycling plant for the Francitas field, Jackson County, Texas. They have taken over the condensate-producing properties of several operators in the field. The plant will be constructed by the H. B. Zachry Construction Company. Initial development includes the drilling of eight wells to depths ranging from 7450 to 8650 ft.

The Government Oil Fields (Yacimientos Petroliferos Fiscales) has recently opened a new refinery at a point known as Tres Cerritos, 3.7 miles from the City of Salta, in the Province of Salta, in the northwestern part of Argentina. According to reports, this plant began operations about February 20, 1941. It occupies an area of approximately 74 acres and has equipment sufficient to treat 1900 bbl. of crude petroleum daily. The capacity of the plant would allow the production of 346,000 bbl. of gasoline annually.

The Houdry catalytic cracking plant being installed at its Bayonne, New Jersey, refinery by the Tide Water Associated Oil Company is expected to be completed by the middle of June.

William F. Humphrey, president of the company, also announces that the capacity of the Tide Water alkylation plant at Avon, California, will be increased in capacity.

Construction of a cycling plant in the West Tuleta field, Bee County, Texas, by Phillips Petroleum Company may result from a deal recently consummated between that company and Anderson-Prichard Oil Corporation and Mills Bennett Production Company. Phillips has exercised an option on the Anderson-Prichard and Mills Bennett holdings whereby for the sum of $40,000 a six-month shooting option was obtained. The latter companies unitized the greater part of the block before the drilling of their first test. Phillips is to complete the unitization of the block and begin a Wilcox sand test within 45 days from date of May 5. The option requires the drilling of a minimum of 6 wells with Phillips reserving the right to withdraw from the contract after the drilling of one test. Mills Bennett and Anderson-Prichard received no cash in the deal but are to get their money from production after the cost of development and the construction of a cycling plant have been paid for. They are to receive one-third of the net distillate and one-half of the oil that is produced.

Two tests have been drilled in the field by Mills Bennett and Anderson-Prichard. One well was abandoned after drill pipe was stuck and the other made a producer. The latter was taken over by Phillips in the deal.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended May 3, 1941
A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	611	95.0	20,787	16,721
Appalachian	91.0	134	94.4	3,151	850
Ind., Ill., Ky.	90.2	594	88.7	18,408	5,810
Okla., Kans., Mo.	76.9	273	84.5	8,399	3,238
Inland Texas	59.6	106	63.5	2,217	1,697
Texas Gulf	89.2	921	96.4	14,978	11,494
Louisiana Gulf	97.6	125	78.1	3,445	3,278
No. La. and Ark.	51.5	49	94.2	597	882
Rocky Mountain	56.0	51	75.0	1,734	646
California	87.3	536	73.4	15,872	77,952
Reported	86.2	3,400	87.0	89,588	122,568
Estimated Unreported		335		6,740	2,155
*EST'D TOTAL U. S. MAY 3, 1941		3,735		(a)96,328	124,723
*EST'D TOTAL U. S. APR. 26, 1941		3,675		96,647	124,275
U. S. B. of M. *MAY 3, 1940		**3,578		103,389	127,784

*Estimated U. S. Bureau of Mines' basis.
**April-May, 1940, daily average.
(a) Finished 88,786,000 bbl.; unfinished, 7,542,000 bbl.

Why Guess...

Left—An A. O. Smith metallurgical report on a series of corrosion tests made in co-operation with a customer to determine which alloy will best meet the specific service requirements.

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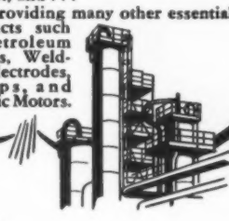

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MAJOR *Oil Field* ACTIVITIES

A NEW Simpson field looms as a possibility for southwest Oklahoma. Robberson No. 4 of Skelly Oil Company and Selby Oil and Gas Company, in CNE NE of 35-1s-5w, near Velma, Stephens County, has showed for a big producer in the Simpson formation at a depth below 7000 ft.

A drill-stem test at 7142 ft., with a ⅜-in. choke on top and bottom and open for 13 minutes, showed sufficient gas and oil to cause company officials to estimate the well is capable of producing 50 to 100 bbl. per hour.

Gulfboard Oil Corporation's State of Texas No. 1-177, a marine wildcat in San Antonio Bay, off the shoreline of Calhoun County, tested oil and salt water at a depth of 6295-6302 ft. and at 6320-32 ft., and the operator was preparing to make a shallow test at 2880-2900 ft. The well is 10 miles southeast of Seadrift. Total depth is 6406 ft.

George E. Reeves has opened a new Viola lime gas pool 8 miles northwest of the Cunningham pool, Pratt County, Kansas. Stark No. 1, in CWL SW NW of 18-26-11w, flowed an estimated 12,000,000 cu. ft. of gas per hour at a depth of 4123-54 ft. after acid treatment.

During the latter part of April four new pools were discovered in Illinois. John Sanders' Leslie Hubble No. 1, 30-2n-8e, in west Zif township, Wayne County, flowed naturally from the McClosky lime at the rate of 100 bbl. per hour. Hinkle and Sloan No. 1 Harrison Cutler, 10 miles southwest of Shelbyville in Shelby County, was completed as a small producer from the Aux Vases sand at a depth of 1775 ft. Production was at the rate of 76 bbl. of oil and 19 bbl. of water in a 48-hr. test. Seiler No. 1 of R. S. Hay and F. H. Brown, 30-1s-12w, in Wabash County, 1 mile southwest of Mt. Carmel, produced 112 bbl. per hour from the Tar Springs sand at a depth of 1784 ft. Cherry and Kidd's Henry J. Karch No. 1 opened a new area in White County, in 24-6s-10e, south of Maunie. The well is a small pumper in the Aux Vases sand at a depth of 2841 ft.

Interest of New Mexico operators is claimed by the possibility that the Grayburg pool of east Eddy County may be linked with the Maljamar field, which is principally in western Lea County. This belief has been strengthened by the gauging of Skelly Oil Company's Beulah V. Lynch No. 2-A, seven-eighths mile southeast of the Grayburg pool and 1¾ miles west by northwest of the Maljamar pool, at 64 bbl. per day on pump.

C. and I. Production Company's and Hebert and Smith's Evangeline Land and Mineral Company No. 1, in the Pine Prairie area of Evangeline Parish, Louisiana, has definitely established a new Yeguna sand pool. The wildcat well flowed 35 bbl. of 40-gravity oil per hour through ¼-in. choke from a depth of 8226-33 ft. Tubing pressure was 1400 lb. per sq. in. and casing pressure 1450 lb. The gas-oil ratio was 900 to 1.

Sun Oil Company has opened a new pool in Chambers County, Texas, with its Felix Jackson No. 3. The well is located in the T. and N. O. survey, 2 miles west of gas-condensate production in the Willow Slough area. Completion was through perforations at a depth of 8250-80 ft.

AVERAGE CRUDE OIL PRICES

California		Louisiana	
Kettleman Hills	$1.19-1.26	Rodessa	.78-1.10
Playa Del Rey	.75- .82	Gulf Coast	.80-1.38
Coalinga	.68-1.10	North Louisiana	.76-1.20
Wilmington	.63-1.21		
Montana	.90-1.15	Illinois	1.05-1.27
Wyoming	.40-1.30	Kentucky	1.05-1.30
Colorado	.95- .97	Indiana	1.12
New Mexico	.77-1.02	Ohio	
Texas		Lima	1.05
North Central	.68-1.08	Michigan	1.17-1.38
Panhandle	.60-1.02		
West Texas	.60-1.02	Pennsylvania	
Gulf Coast	.96-1.38	Bradford	2.40
Darst Creek	1.04	Southwest	2.05
East Texas	1.15	Eureka	1.89
Talco	.72	Buckeye	1.55
Kansas	.75-1.15	Corning	1.24
Oklahoma	.75-1.15	Canada	2.10-2.17
Arkansas	.58- .98		

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

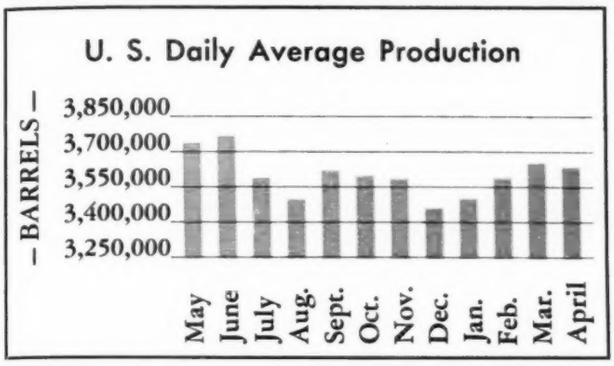
(Figures in bbl. of 42 gal. each)

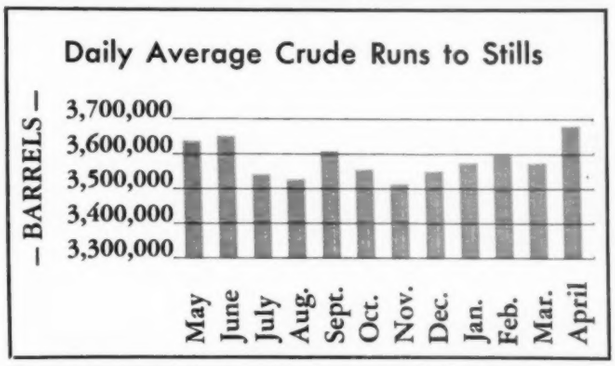
	[1]B. of M. Calculated Requirements (April)	Week Ended May 3, 1941	Week Ended March 29, 1941	Week Ended May 4, 1940
Oklahoma	429,300	[2]408,650	408,450	409,350
Kansas	200,700	[2]209,100	211,650	147,650
Nebraska	4,300	[2] 4,200	4,350	.....
Panhandle Texas	.....	76,850	77,450	77,550
North Texas	.....	95,850	101,650	102,600
West Central Texas	.....	29,950	30,600	33,050
West Texas	.....	210,250	241,400	233,300
East Central Texas	.....	74,950	77,900	80,900
East Texas	.....	304,000	445,000	396,650
Southwest Texas	.....	175,100	210,200	214,100
Coastal Texas	.....	232,800	257,100	229,650
TOTAL TEXAS	1,355,300	1,199,750	1,441,300	1,367,800
North Louisiana	.....	72,100	70,800	69,500
Coastal Louisiana	.....	235,450	235,250	224,500
TOTAL LA.	299,700	307,550	306,050	294,000
Arkansas	75,700	72,350	70,950	69,100
Mississippi	20,300	[2] 28,450	17,750	7,800
Illinois	336,000	322,900	325,200	421,550
Indiana	23,700	[2] 21,800	19,850	9,600
Eastern (not incl. Ill. & Ind.)	100,700	93,250	93,200	100,400
Michigan	44,000	38,000	37,900	62,250
Wyoming	88,700	73,600	74,350	66,400
Montana	21,300	19,100	18,200	17,500
Colorado	4,300	3,800	3,850	3,750
New Mexico	109,000	108,800	109,000	106,800
TOTAL EAST OF CALIF.	3,113,000	2,911,300	3,142,050	3,083,950
California	596,300	595,800	604,500	595,100
TOTAL U. S.	3,709,300	3,507,100	3,746,550	3,679,050

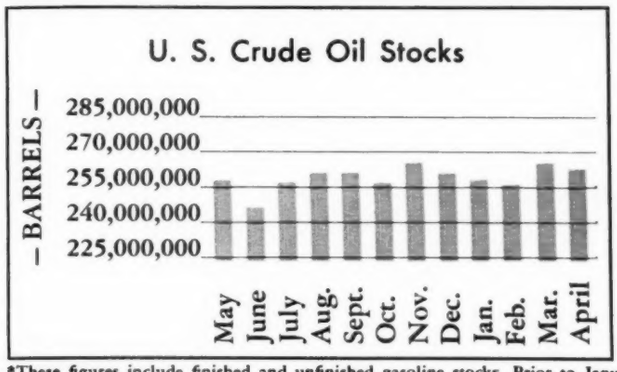
[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of April. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

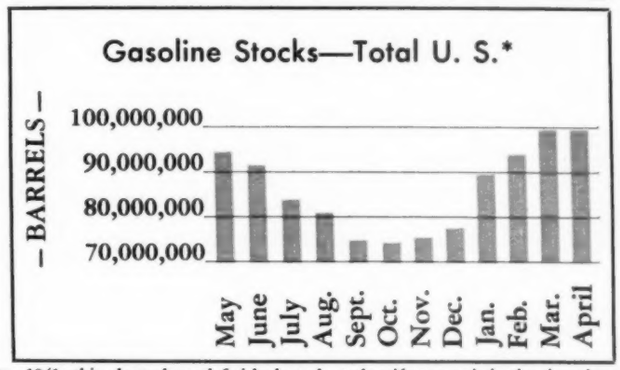
[2]Oklahoma, Kansas, Nebraska, Mississippi, and Indiana figures are for week ended 7 a. m. April 30.

PETROLEUM *Statistics* AND FIELD *Operations*









*These figures include finished and unfinished gasoline stocks. Prior to January, 1941, this chart showed finished stocks only. Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for April, 1941

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	46	46	7	30	3500-3700	2	40	Rotary
Duval County	23	15	4	14	1554-2900	2	22	Rotary
Ector County	28	28	14	39	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	57	55	25	89	1700-3900	2	40	Rotary
Nueces County	32	28	5	11	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	16	15	8	29	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	19	19	10	20	4495-4912	2	19-29	Rotary
OKLAHOMA								
Fitts Pool	3	2	1	3	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	29	24	4	17	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	27	24	8	21	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	30	18	17	30	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	307	243	312	157	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	16	16	9	26	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	1	1	1	9	8300-8730	3 or 4	40	Rotary
Wilmington	10	10	13	10	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for April, 1941

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1940 (In Barrels)
	April	March	April	March	April	March	April	March	April	March	
Arkansas	11	13	3	7	21	8	5	2	25	20	25,699,000
California	93	89	89	80	115	90	70	57	149	139	224,029,629
Colorado	1	1	0	1	....	....	3	1	35	33	1,369,788
Illinois	307	242	243	185	416	392	312	262	157	105	146,572,938
Indiana	44	38	28	26	....	....	11	6	67	56	4,946,384
Kansas	189	156	153	120	227	152	38	33	248	213	65,602,452
Kentucky	29	13	11	3	....	....	8	9	88	90	5,282,335
Louisiana	112	96	77	74	169	148	46	39	319	274	103,738,728
Michigan	71	68	44	27	75	72	40	37	149	145	19,768,984
Mississippi	10	18	8	15	....	....	3	2	27	21	4,313,159
Montana	15	14	13	12	....	....	5	4	65	66	6,663,872
Nebraska	7	2	4	0	8	5	3	2	20	19	267,533
New Mexico	35	33	30	26	36	44	18	19	117	121	38,893,898
New York	64*	57*	64*	57*	....	....	7	9	60	66	4,240,441
Ohio	159	97	127	84	....	....	51	45	201	167	3,132,280
Oklahoma	189	148	125	113	231	152	47	41	296	260	152,516,049
Pennsylvania	206*	179*	197*	169*	....	....	....	....	....	....	17,987,217
Texas	887	778	671	581	1291	1235	614	514	1831	1557	490,101,261
West Virginia	56	41	48	35	....	....	25	23	154	151	3,586,653
Wyoming	7	6	7	5	....	....	13	10	65	60	25,863,538
Total	2492	2089	1942	1620	2589	2298	1319	1115	4073	3563	1,344,576,159

*Includes water-intake and pressure wells.

MAJOR *Pipe Line* ACTIVITIES

STANDARD OIL Company of Indiana has awarded contracts for the construction of two lines that will extend from the company's Sugar Creek-Council Bluffs gasoline trunk line. To Williams Brothers Corporation has been granted a contract for 109 miles from Burlington Junction, Missouri, to Des Moines, Iowa. For the laying of 168 miles of line between Council Bluffs, Iowa, and Sioux Falls, South Dakota, the contract has been divided. Ray L. Smith Contracting Company will lay the section from Bronson, Iowa, to Council Bluffs. Jones and Brooks, Inc., will construct the section between Bronson and Sioux Falls. These lines will be of 6-in. pipe.

Standard Oil Company of Indiana also has announced that a 147-mile, 8-in. line will be laid from the company's Whiting, Indiana, refinery to Indianapolis, Indiana, for the transportation of gasoline and other refined products.

O. C. Whitaker Company will lay a pipe line for Socony-Vacuum Oil Company, Inc., a gasoline and refined products line, to connect Syracuse and Binghamton, New York. The new line will tie-into the line constructed by the company last year from its refinery at Buffalo to Syracuse.

Stanolind Pipe Line Company has awarded a contract to Rogers and Vaughn for the laying of 26 miles of 6-in. oil line and the taking up of 24 miles of 4-in. line in Montague County, Texas. This contractor is also laying 8 miles of 4-in. line for Stanolind in the Voth pool, Texas.

Canadian Western Natural Gas Light and Power Company will lay 100 miles of gas line this summer to transport natural gas from the Kinsella field, near Viking, to Red River, Alberta, Canada. Gas will also be supplied consumers in Wetaskiwin, Ponoka, and Red Deer. Construction will be by the company's own engineering department.

Latex Construction Company, Houston, Texas, and B. and M. Construction Company, Oklahoma City, Oklahoma, have been awarded the contract to lay Globe Oil and Refining Company's 225-mile, 6-in. gasoline pipe line from McPherson, Kansas, to Council Bluffs, Iowa. B. and M. will construct 100 miles at the south end of the line and Latex will lay 126 miles on the north end.

The Federal Power Commission has announced that the Kansas Pipe Line and Gas Company's application for authority to construct a pipe line from the Hugoton gas field in Kansas to the Mesabi Iron Range has been dismissed without prejudice because the company failed to prosecute its proposal.

The company's application for permission to lay the line to serve distributors and consumers in Kansas, Nebraska, South Dakota, North Dakota, and Minnesota, was filed in 1938. Cost of the proposed line was estimated by the applicant at $14,550,000.

The Bell Oil and Gas Company of Tulsa, Oklahoma, has sold its 50 percent interest in the General Bell Pipe Line Company, a gathering system in the East Texas field, and the General Bell Transit Company, an ICC carrier from Overton to Bullard, Texas, where it connects with the line of the Pure Transportation Company, to the General American Oil Company of Dallas. The latter company now owns the system 100 percent and is said to be considering its sale to the Pure Oil Company, owner of the Pure Transportation Company.

Howard J. Sherman and Associates have completed the laying of a 4-in. pipe line from the Hobart field, Kiowa County, Oklahoma, to a loading rack near Hobart.

Aetna Oil Company of Louisville, Kentucky, will lay a 4-in. oil line from the Inman field, Gallatin County, Illinois, across the Wabash River to a loading terminal at Mt. Vernon, Indiana, a distance of 14 miles. The line will originate on the Egyptian Tie and Timber Company leases near Inman where several Tar Springs producers have been completed recently with initial gauges of from 200 to 400 bbl. per day. At present Aetna is trucking the oil to gathering lines.

The indemnities provided in the law concerning the nationalization of pipe lines in Rumania are determined by a committee that is composed of one member each of the empowered representatives of the ministry of economics and of the former owners and the president of the district court of Ilfov, says a translation from *Oel and Kohl*, Berlin, and reported by the U. S. Department of Interior. In the valuation the demonstrable costs of construction are taken into account, less the monetary value of the degree of depreciation. The decision of the committee may be contested within 15 days before the court of appeals at Bucharest, which has to make its decision by an accelerated procedure. Against this decision a review by the court of cassation is possible. The indemnity will be paid in 3 percent state bonds, which will be amortized within 25 years.

H. C. Price Company of Bartlesville, Oklahoma, has been awarded contracts for electric welding of the following pipe lines:

For Natural Gas Pipeline Company of America, 121 miles of 26-in. comprised of 33 miles from Stinnett, to Spearman, Texas, and 88 miles from Meade to Kinsley, Kansas. The general contractor is W. A. Bechtel Company.

For Natural Gas Pipeline Company of America, 101 miles of 26-in. in Iowa and Nebraska; general contractor, O. E. Dempsey Construction Company.

For Natural Gas Pipeline Company of America, 88 miles of 26-in. in Iowa; general contractor, W. A. Bechtel Company.

For Natural Gas Pipeline Company of America, river crossings in Iowa; general contractor, W. A. Bechtel Company.

For Consumers Power Company, 40 miles of 12-in. near Clare, Michigan; general contractor, Dowding Truck and Transfer.

For Illinois Pipe Line Company, 27 miles of 10-in. and 40 miles of 8-in. near Bridgeport, Illinois; general contractor, Sheehan Pipe Line Construction Company.

For Southern Natural Gas Company, 132 miles of 14-in. from Logansport to Perryville, Louisiana; general contractor, B. and M. Construction Company.

For Stanolind Pipe Line Company, 76 miles of 8-in. and 12-in. from Belcherville, Texas, to Pauls Valley, Oklahoma; general contractor, B. and M. Construction Company.

For Stanolind Pipe Line Company, 40 miles of 12-in., consisting of 24 miles near Carrollton, Missouri, and 16 miles near East Ft. Madison, Illinois; general contractor, Oil States Construction Company.

P 425.214.

THE Petroleum Engineer

MAY, 1941

Drilling Bit Performance in California Operations

Exclusive

☆ Records of all pertinent factors in drilling when properly correlated form basis for intelligent analysis of bit usage—effective bit service also revealed when high rotating speed is co-ordinated with weight on bit

By Wallace A. Sawdon
Pacific Coast and Foreign Editor

THE REMARK was recently made by an engineer of one of the leading oil companies in California that "we don't use bits; we abuse them." Though this remark was based on experience by a man who had roughnecked and drilled on many wells, it was, of course, somewhat extreme and was made with the object of expressing sententiously the idea that much could still be learned about obtaining more effective bit performance. Manufacturers have designed bits to meet the requirements of the various formations encountered while drilling and bits are being selected intelligently for the duty they are to perform. But as every operator wants the most of the best hole for the least outlay of money, there is probably reason for further study of performance data.

Bit records are assiduously kept by most operators and information disclosed by such records has aided materially in getting better results. Unfortunately there are so many factors that influence bit performance that the factual data derived from bit records of one or more companies cannot be relied upon to provide a guide for general operating conditions, even for one specific field. Even the casing program planned by one company may cause the use of a different number of bits to drill to the same depth than the program of another company that plans for a different size hole. This does not always mean that the smaller hole requires less bits or drills faster despite the fact that less formation is cut and carried to the surface. Actually, it would appear from present observation that with everything else being equal, hole below the surface string being drilled with rock bits will go faster with larger bits (within a range of 10⅝ in. to 12¼ in.) and it is safe to say that the driller can run harder on the larger bits. To state this as a rule would be unwise, however, for the personal element enters into the operation.

This personal element goes further than the man with his hand on the brake. As brought out by C. A. Yeatman[1], the "driller has been a reasonably reliable source of formational information" and has in the past changed the rate of rotation and, more particularly, the weight carried on the bit when the formation changed. Now the rotating speed and weight to be carried are frequently predetermined for the driller and when this is done with due consideration of all the factors involved there should be faster penetration with longer bit life and more hole made between trips.

All this is a step in the right direction provided the bit movement is based on a coördination of all factors, which include surface equipment, drill string, depth of hole, circulating pressure and volume of mud, and the formation being drilled. The trend is toward higher rotating speeds and less weight on the bit, but in many cases there is a probability that the speed and weight have been arbitrarily set. Better bit performance has certainly accompanied the intelligent application of speed and weight control, but in a field where formations are known and depths can be closely estimated there might be even better control with varying speeds and weight for the drilling of different formations at different depths. Valuable data could probably be procured by following the suggestion of one engineer: that an experimental hole be drilled in a field such as Montebello where formations of many types are encountered and in this hole try out different rotating speed and weight combinations with the proper types of bits as designed by the manufacturers for the particular hardness of formation. Such a project would, however, be rather expensive and a newly developed rate-of-penetration instrument may yield comparable data during the drilling of development wells.

The fundamental principles of this instrument are described in the A.P.I. paper already referred to[1]. Another instrument, more recently developed, gives on one record sheet the rate-of-penetration, the weight carried on the bit, the rotating speed, the circulating pressure, and the torque. This instrument has been in service for too short a time to provide adequate data on its

[1] "Practical Utilization of Rate-Of-Penetration Drilling Data" by C. A. Yeatman, read before the Spring Meeting, A.P.I., Los Angeles, March 19, 1940.

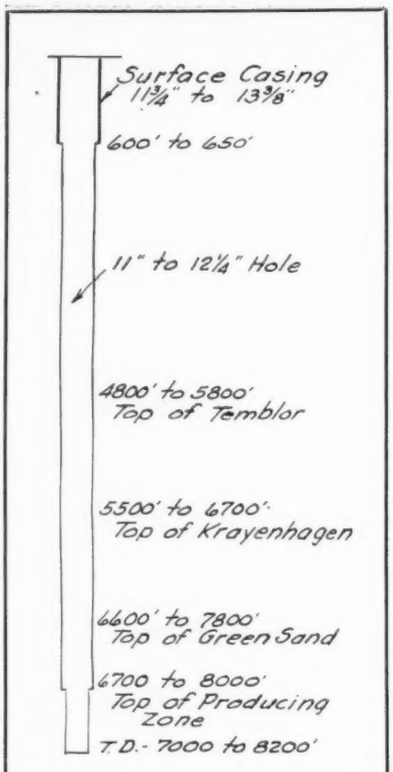


Fig. 1. Typical drilling program in the Coalinga Area, California. Surface drilling is by special drag bits

application for determination of bit performance but it appears to offer opportunities for observing the rate of penetration under variations of rotating speed, weight, and pump pressure. As the records are correlated on the one sheet by time intervals, the effect of any change in weight, speed, or pressure should be immediately reflected by the rate of penetration if such changes actually affect the rate. The rate of penetration is affected by the condition of the bit, so bit wear must be taken into consideration.

Formations encountered in California drilling lend themselves to the utilization of many types of bits. In many wells, the softer, upper formations are drilled with drag bits or with special bits. In Ventura, for example, some 7200-ft. wells are drilled to half their depth with a special type of bit, which has a cutting head that revolves differentially around an axis inclined from the axis of the drill string. The lower, harder formations are drilled with rock bits. In some fields the rock bit is used from the grass roots down.

In this discussion no distinction is made between the cone and roller types of rock bits nor between different designs of the various types. Bit manufacturers are supplying bits that will drill through formations of different hardness and character most effectively and economically, and the operator can readily select the type of bit that best meets his conditions.

Bit performance in one field is not always a guide to bit selection for use in another. The general use of bits in drilling the Coalinga Nose or East Coalinga Eocene indicates how practices vary even within one area. The general distribution of the formations is indicated in Fig. 1 where drilling for the surface string is done with special or drag bits.

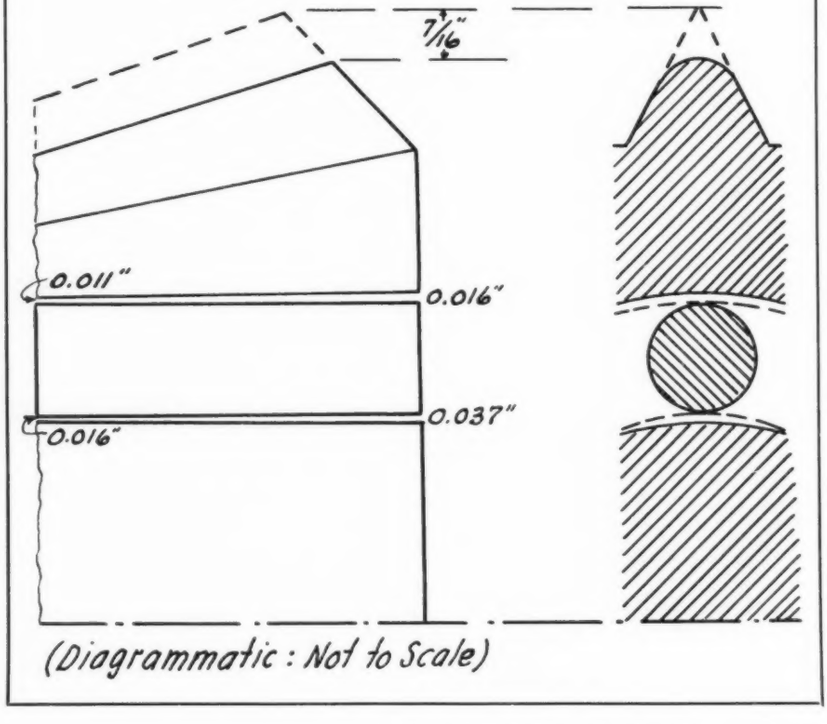
Rock bits used from the bottom of the surface pipe to the top of the Temblor formation vary in size from 10⅝ in. to 12¼ in. and are designed for fairly soft and unconsolidated formations. The first bit is expected to drill from 1000 to 2000 ft. of hole and from there the depth per bit will decrease gradually to 500 ft. until the top of the Temblor is reached. The speed in drilling these formations will range from 100 ft. per hour to 35 ft. per hour.

The Temblor is approximately 1000 ft. thick and bits suitable for medium rock formations are used. In some wells from 60 to 100 ft. per bit is obtained in this formation, but in other wells not more than 50 ft. per bit may be obtained. On reaching the Krayenhagen, which also is approximately 1000 ft. thick, variation in bit footage is even greater than in the Temblor. The Krayenhagen is made up of three parts—the upper, middle, and lower—the lower 300 ft. being hard formation. In some wells bit footage of 25 to 40 ft. is obtained, but in other wells as much as 100 ft. per bit has been obtained.

The oil sands are below the Green sand and the water string is set on top of the producing zone. Drilling-in is done with bits ranging in size from 5⅞ in. to 7⅝ in. and suitable for medium rock drilling. A minimum of 25 and a maximum of 50 bits per well have been used in this field. Evidently there is great variation in the performance of bits in this area, which is also one in which crooked holes must be guarded against. In general, the hole has a tendency to deviate from the vertical at the top of the Temblor and then straighten up. Then when reaching the top of the Krayenhagen the hole again tends to go crooked.

How much of the penetration in California fields is due to hydraulic action of the circulating fluid cannot even be estimated. With the high-pressure, large-volume slush pumps being used for deep well drilling there is probably a considerable effect from washing action in the upper formations. The effect of this washing action will vary with the softness and character of the formation. It is be-

Fig. 2. Showing the relative wear on the teeth and bearings of a rock bit operated at a rotating speed of 300 r.p.m. and a weight of 3000 lb. on the bit. Bit had been pulled before wear became excessive



lieved that a washing action rather than a jetting action results from the present design of bits, the circulation ports being arranged to provide for cleaning of the teeth as well as for cooling the bit.

California has been somewhat noted for high speed of rotation. When it comes to speeds of 500 r.p.m. and above, however, it must be remembered that such speeds are not general and have, to date, been confined to the area in and around the Rio Bravo field in the northern end of the San Joaquin Valley. Yet the trend toward increased rotating speed has been evident during the last few years and in a considerable amount of drilling in the formations the speed has averaged from 300 to 350 r.p.m. In the slim-hole drilling being done in one field, where casing is used as drill pipe, the speed has probably been approximately 300 r.p.m. for the greater portion of the depth. In most fields where speeds of 300 to 350 r.p.m. are carried after setting the surface string, the rotation is decreased to 200 or 175 r.p.m. when the harder formations are reached. Some companies use speeds of 150 r.p.m. and less in hard digging in order to get a bounce on the bit.

Coördination of rotating speed and weight carried on the bit has probably been the secret of most effective bit performance; yet, although high rotation generally requires a corresponding reduction in weight, there have been numerous cases where the weight carried with speeds of 400 r.p.m. and over has been greater than is generally considered feasible. This has been so while drilling a number of the wells at Rio Bravo, and the mud circulation having been great in such cases the possibility of the influence of the circulating fluid should not be overlooked. Correlation of rotating speed and weight with circulation pressure and volume should thus possibly be given greater attention for the particular formation being drilled.

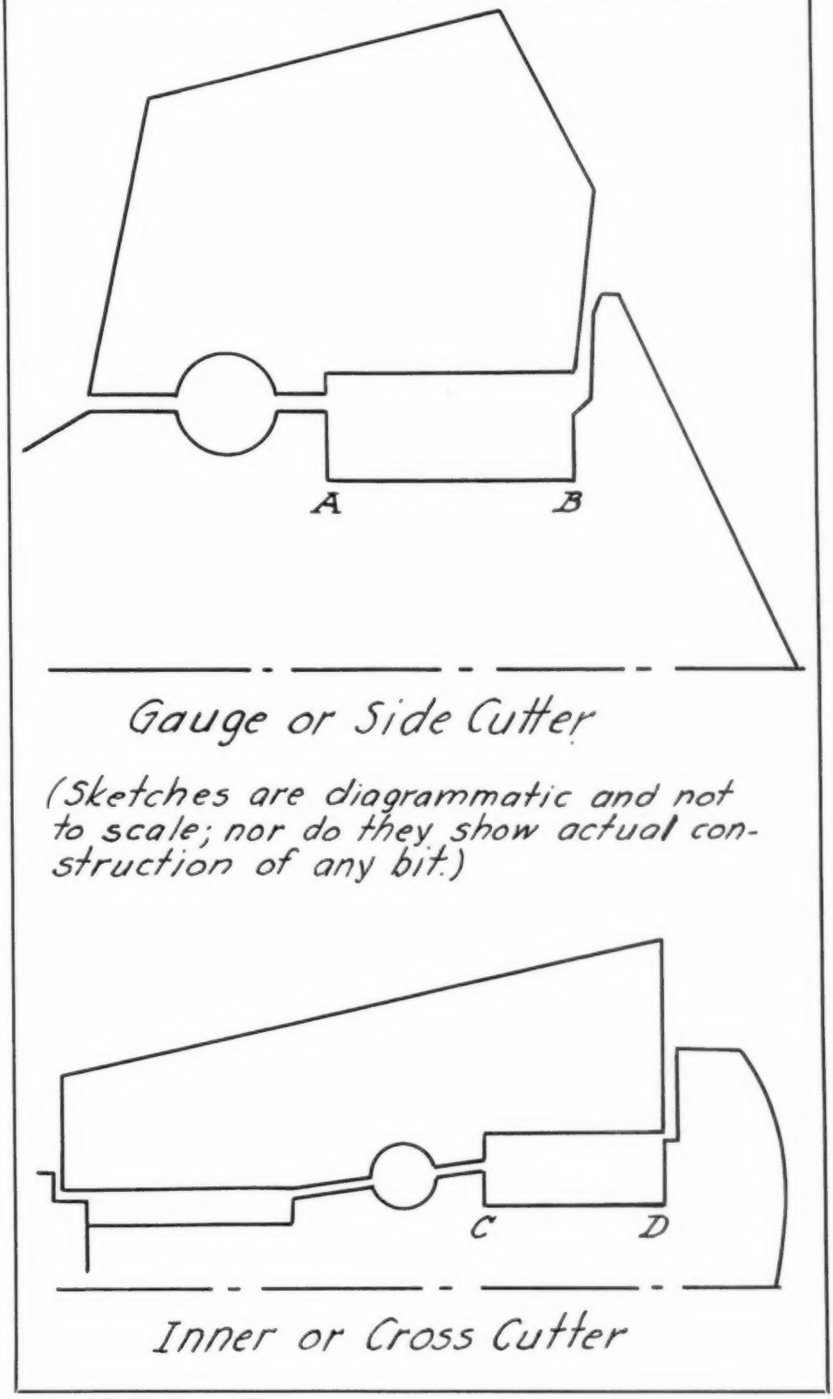
Considering weight alone, it varies, in the words of one engineer, "all over the map." To refer to the Coalinga Nose operations just cited, the weight carried on the bit to the top of the Temblor will be as great as 20,000 lb. Below this depth the weight is seldom more than 15,000 lb. and some operators here carry only one point on the weight indicator. In the Los Angeles Basin operations the rule is to maintain from 3 to 4 points with a 6-point maximum. These are rather general statements, however, and the actual weight put on the bit may vary considerably from these figures.

When to change the bit is a problem usually left to the driller. It is

TABLE I

Bit	Wear at: "A"	"B"	"C"	"D"	Avg. wear
"X"	0.042 in.	0.068 in.			0.055 in.
"Y"	0.036 in.	0.047 in.			0.041 in.
"X"			Avg. Several		0.034 in.
"Y"			0.028 in.	0.047 in.	0.038 in.

Fig. 3. Sketch showing wear points as listed in Table 1 in which comparative wear data are given for two bits subjected to different operating conditions


A
B
Gauge or Side Cutter
(Sketches are diagrammatic and not to scale; nor do they show actual construction of any bit.)
C
D
Inner or Cross Cutter

probably an unusual case in which a bit is pulled before the teeth are so worn that the bit is no longer digging effectively. On the other hand, the driller usually knows when the bit gets dull and his estimate of the time to change bits is generally rather accurate. There are many cases in which the bits come out of the hole with very little of the teeth left. Bit wear, however, is not confined to the teeth and sometimes may be excessive on the bearings. The relative wear on the teeth and bearings of a rock bit (that had been drilling at a rotating speed of 300 r.p.m. and a weight of 3000 lb.) and was pulled before wear became excessive, is indicated by Fig. 2. It will be noted that the wear at both the top and bottom of the roller bearing is greater at the outer end. This has generally been found to be the case and is probably due to sand particles from the fluid being themselves worn smaller as they wear away the bearing on their passage inward.

The theoretical wear on bearings is proportional to the speed in r.p.m. multiplied by the square root of the weight carried on the bit. The result of this computation is not a figure of measurement but rather one for the purpose of comparison. For example, take two bits that were run at different speeds of rotation with correspondingly different weights, but both of which were pulled when the wear on the teeth was about the same. The first bit "X" was run at 300 r.p.m. with 1½ points of weight, or 3000 lb.; the second bit "Y" was run at 120 r.p.m. with 10 points of weight or 20,000 lb. The wear on the bearings shown in Fig. 3 at "A" and "B" for the gauge or side cutters and at "C" and "D" for the inner or cross cutters was found to be as shown in Table 1.

Computing the theoretical proportional wear from the formula, the indicative unit for wear on bit "X" is 16,500 and that on bit "Y" is 17,000. This would indicate that the wear on the bearings of both bits should be approximately the same, or that the wear is slightly greater on the one rotated at slower speed. Actually, the wear on the rollers of the outer cutters was a little greater for the bit rotated at higher speed; on the rollers of the inner cutters, however, the wear was slightly less.

When the bit is run too long the wear on the bearings is likely to be excessive, no matter what the type of rock bit. There is certainly no advantage in running a dull bit, because the teeth are not there to cut the formation and the rate of penetration is being constantly reduced. Very high speeds (400 r.p.m. and greater) have been used only with bits of 11 in. or larger, for it is believed that the bearings on smaller bits cannot stand up under the high speeds. Actually it is doubtful whether there have been occasions when it was desired to run smaller size bits at speeds above 400 r.p.m.; but if the time comes when such speeds with smaller bits are required, the bit manufacturers will probably have bits ready for that duty.

P 111.14

Deep Rotary Well in Appalachian Region

ATTRACTING considerable interest among those who have contemplated the possibilities of deeper drilling in the eastern part of the United States is the exploratory well recently completed at a depth of 10,018 ft. Thus far, there have been no commercial discoveries made but the well is important because it may serve as the incentive for other deep tests in West Virginia.

The well is on the C.S. Gribble farm in the Grant District, Harrison County, West Virginia, about two miles east of Lost Creek and approximately twelve miles southeast of Clarksburg. It was drilled for the Hope Natural Gas Company of Clarksburg by the Falcon Seaboard Drilling Company of Tulsa, Oklahoma, and Houston, Texas.

Rotary equipment was moved by the contractor from Donaldsonville, Louisiana, to Lost Creek via freight in June, 1940. The drilling crew totaling 19 men was moved to West Virginia to operate the rig. J. C. Hunter from Midland, Texas, was the toolpusher on the job.

The equipment employed in drilling the well was typical of the heavy rigs used on the Gulf Coast designed for 10,000-ft. drilling. Three 250-hp. V-8 gas engines supplied power to the mud pumps and generated d-c. current for the 300-hp. electric motor driving the drawworks and the rotary table. The drill pipe was 4½-in. external upset, internal flush equipped with 6¼-in. O. D. tool joints. A 136-ft. derrick having a 26-ft. base was mounted on an 8-ft. substructure. Rock bits were used for the entire hole.

Rotary drilling began on July 4, 1940, after the surface hole had been drilled by a spudding machine and 173 ft. of 16-in. casing had been set and cemented. Hole diameter to a depth of 985 ft. was 13¾ in. At the latter depth, 10¾-in. O. D. casing was set and cemented. The hole was then reduced to 9⅞ in. and the well was deepened to 9902 ft. and then reduced to 9-in. diameter for completion of the drilling to the total depth of 10,018 ft.

The upper formations encountered in the well had been fully explored previously by cable-tool drilling to a depth of approximately 4000 ft., inasmuch as the well was situated in an old gas field. Below 4000 ft. the Devonian shales were drilled to a depth of 7060 ft. where the top of the Huntersville Chert was encountered. This formation was characterized as predominately dark chert with some limestone and shale. The top of the Oriskany Sand was encountered at a depth of 7290 ft. The slight gas show in the latter formation was tested by drill-stem test but did not indicate a commercial well. Following the test it was decided to deepen the well through the White Medina Sandstone.

The formations from the base of the Oriskany to a depth of approximately 9200 ft. consisted of limestone, dolomite, anhydrite, and salt. There was some indication of sulphur gas noted in these formations. From 9200-9750 ft. the formations were predominately the red and green shales of the Clinton series. A show of gas was encountered at 9650-85 ft. in sandy shales. This show was tested by drill-stem test with negative results. The White Medina formation was about 250 ft. thick and was found to be a very hard, dense, flinty sand with no gas shows and no measurable porosity.

A string of 7-in. O. D. casing was run and cemented at 8205 ft. on April 9, 1941, to test the sulphur gas shows. The well was bailed to a depth of about 9000 ft. with a slight show of gas. The casing has recently been shot at about 8000 ft. and is being pulled and reset in the top of the Huntersville Chert to test the Oriskany Sand further.

Because of the interest in this well, the Hope Natural Gas Company plans to prepare a technical report, describing the drilling operations on this well. Further technical data have been prepared and will be included in that report.

P 615.635.4

A Rational Approach To Cathodic Protection Problems

PETROLEUM ENGINEER Exclusive Feature

☆ Attention is called to the need for more detailed tests than are normally made—Criteria of protection should be viewed with caution

PART I

by Gordon N. Scott, Consulting Pipe Line Technologist

Introduction

RESPONSIVE to repeated demands for information on methods of measuring the radial currents entering or leaving a pipe line through the soil and especially the conductance of a pipe coating and related measurements, the writer has developed in detail in the following pages a function and its application to cathodic protection.

The methods of measurement and analysis described are of practical importance and are especially applicable to problems in which poorly treated or bare pipe lines are involved. Accordingly, it is a further purpose by setting forth the complete theory to provide a tool that corrosion engineers may employ to extend forced drainage to bare and poorly treated pipe lines.

Furthermore, many investigators lack proper appreciation for the importance of the geometrical factors associated with measurements of the electric potentials about a pipe line in the soil and are thus possibly led to a false sense of security in the use of a potential "reading" of a certain value that has been established as protective more through rule of thumb and experience than upon sound principles.

To fulfill these several purposes, therefore, the subject is treated fully, first in theory, then in more practical terms, so that the reader, by study and by measurements on pipe lines, may develop a full understanding of the subject. It is not expected that the reader will become proficient in the use of the methods on casual reading but trial of them in the field will quickly clarify the somewhat baffling array of symbols and relations. In addition the text will provide a useful reference for the several equations in their applicable forms.

Emphasis is laid on the mechanics of the approach to the problem. Interpretation of results is reserved for a future article.

GORDON N. SCOTT

received degrees of A.B. in chemistry, B.S. in chemical engineering, and Ph.D. in physical chemistry from University of California—First connected with petroleum industry when employed by Mid-Continent Petroleum Corporation as research chemist in 1927—From April, 1928, to December, 1934, employed by the Corrosion Committee of the American Petroleum Institute as research associate at National Bureau of Standards to study pipe-line corrosion and protective coatings—From January, 1935, to January, 1936, A.P.I. pipe-line technologist at Dallas, Texas—Since then has been consulting pipe line technologist, Los Angeles, California.

Derivation of Basic Equations(1)

We wish to find the distribution of the electric potential about a cylindrical conductor of radius a,(2) in centimeters, in an infinite conductor of resistivity ρ, in ohm-cm.

In Fig. 1 is shown a cross-section of such a conductor or pipe line in a plane, hereinafter referred to as the test plane, perpendicular to the longitudinal axis of the pipe line. Ignoring the soil boundary shown in the figure it is evident that at the distance, r, in centimeters, from the center of the pipe line in the test plane the current, i, in amperes, enters or leaves the pipe radially per cm. of length through the conducting medium at a density, i_0 (in amp. per sq. cm.) equal to $i/2\pi r$. Whence from Ohm's Law:

$$-\frac{dV}{dr}=\frac{i\rho}{2\pi r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where V is the potential in volts and where i is taken as positive if the current flow is in the direction of increasing values of r.

Integrating,

$$V=\frac{i\rho}{2\pi}\ln^{(3)} r+C \quad . \quad . \quad . \quad (2)$$

where C is the integration constant.

When $r=a$, $V=V_a$ whence:

$$C=V_a-\frac{i\rho}{2\pi}\ln a$$

and

$$V_r=V_a+\frac{i\rho}{2\pi}\ln r/a \quad . \quad . \quad . \quad (3)$$

Equation (3) is the basic equation upon which all others to follow depend. It is true under the conditions set forth in which it was tacitly assumed that current components other than radial were zero.

The voltage, V_a, on the surface of the pipe is not yet defined, but it may be considered to be the sum of those potentials (including polarization) that are associated with the film constituting the immediate environment of the pipe. V_a includes also the potential of the reference electrode. It is the potential of the pipe with reference to an arbitrary reference electrode positioned at $a+\xi$, where the very small quantity $\xi \neq 0$† but is negligible in magnitude with respect to a. The phrase, "potential of the pipe," has no meaning in fact, but what is meant by the phrase is the potential of the pipe with refer-

(1) The author is indebted to Dr. J. M. Pearson for the derivation as given here and for the concept of the "electrical radius."

(2) In following the development and in applying the equations presented it will be necessary to keep in mind a large number of symbols. Accordingly, to assist the reader in grasping the arguments in the text the symbols used and some of their relations are grouped in Appendix A.

†$\xi \neq 0$ denotes "ξ is not equal to zero."

(3) The natural logarithm is written ln and the common logarithm is written log. It should be noted that although r and a are in centimeters, in applying the equations to follow to a pipe line, these same unchanged symbols will then be in inches.

ence to some arbitrary or convenient level in potential or, practically, with respect to an electrode at some particular point in the conducting medium. It is evident that the relation expressed by equation (3) is independent of the assigned reference potential, providing the reference potential is constant and, unless the reference is stated, the values of V_r and V_a are of little significance *per se*. Fortunately, however, we shall be principally interested in "differences" of potential; hence, the reference potential, at least temporarily, is of secondary importance and its absolute value need not be known to derive fairly complete information from equation (3). Notwithstanding this fortunate circumstance we shall eventually have occasion to inquire into the components of V_a. In the meantime, however, V_a may be viewed as the residual potential when from a reading, V_r, all *ir* drops through the conducting medium and coating have been eliminated.

Requisites of the chosen reference electrode are (1) that it be constant during the test and (2) that the portion of the measured potential or "reading" due solely to the reference electrode be reproducible in respect to time so that always the same reference may be employed to deduce such changes in potential (as from polarization) that may occur in point of time.

The writer has found the "copper-saturated copper-sulphate half-cell" excellent for the purpose at hand and accordingly when values of V_r are given in this article it will be understood that the values include the mentioned half-cell potential, together with such polarization potentials and *ir* drops as may be included in the reading.

Inspection of equation (3) shows that the voltage reading or potential of the pipe line as we shall hereinafter call the reading at any point in the medium, is directly proportional to the resistivity, ρ, in ohm-cm., of the medium and to the radial current entering or leaving the surface of the pipe line in the test plane. It is also evident that the potential varies logarithmically with the purely geometrical factor, r.

We may differentiate equation (3) with respect to any of the variables, ρ, i, or r. In a practical sense the environment is not subject to variation at will as are i and r, hence the derivative with respect to ρ leads to no useful practical application. The derivative with respect to r leads back to equation (1); we shall have occasion to use this important relation in the form:

$$\frac{dV}{d\ln r} = \frac{i\rho}{2\pi} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

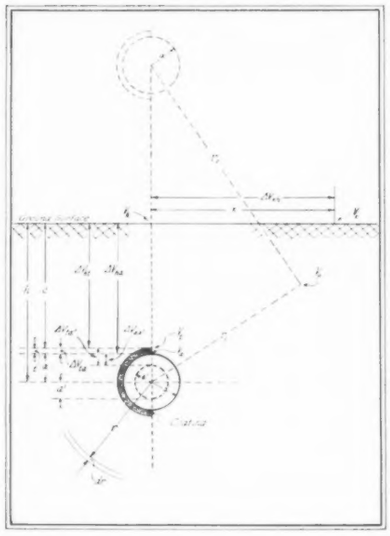


Fig. 1. Some important geometric relations of a buried pipe line

The derivative of V with respect to i, namely:

$$\frac{dV}{di} = \frac{\rho \ln r}{2\pi} + \frac{dV_a}{di} \quad . \quad . \quad . \quad . \quad (5)$$

is less important than is the derivative of V with respect to both i and r, which may be written:

$$\frac{d^2V}{di\, d\ln r} = \frac{\rho}{2\pi} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The three differential equations have in common the absence of the residual potential, V_a, if we assume $\frac{dV_a}{di} = 0$ which is often true. Each derivative is, therefore, entirely independent of the potential of the auxiliary electrode as the potentials are differences or increments. It is tacitly assumed that C or its boundary counterpart, V_a, is unaffected by the variation in r and by an instantaneous variation in i. This assumption is strictly true for the variations in r but is not necessarily so for those in i. V_a is a function of time and as i changes so must V_a.

Equations (3), (4), (5), and (6) are all of value in determining i when ρ is known inasmuch as by fixing the limits of the geometrical quantity r, i may be calculated simply by measuring the corresponding value of V or the increments in V. All differentials may be replaced by finite increments as variations in V are entirely linear with respect to both i and $\ln r$.

A further use of equation (4) lies in so fixing the limits of the logarithmic geometrical factor that the measured value of $\Delta V_{r''r'}$ between r' and r'' is also a measure of the change in potential $\Delta V_{r'a}$ between r' and a. In this way V_a may be approximated.

Equation (5) is, among other things, primarily useful in studying the effect of cathodic currents with time and in obtaining part of the data needed to calculate the coating conductance.

Equation (6) is used in conjunction with equation (5) principally to measure the conductance of the coating in the test plane. Its use is dependent upon an external source of soil current, I, as in a typical cathodic protection installation, and upon means to interrupt this current. For example, and as similarly explained above, $\Delta \ln r$ is so fixed between r'' and r' that the drop in potential between r' and r_a, due solely to the fraction α of the current I entering the pipe in the plane of test, is measured by $\Delta^2_i V_{r''r'}$. Then if ρ is known, $i = \alpha I$ may be calculated. Accordingly, the potential drop through the coating is given by the difference between $\Delta_i V_{r'}$ of equation (5), $\Delta V_a = 0$ (when $r = r_1$), and the measured value $\Delta^2_i V_{r''r'}$. The resistance of the coating or the conductance is then found by dividing the potential drop through the coating by the current that caused it.

TABLE I

Potential profile on a bare pipe line

x (ft.)	V_x*	V'_x	$\Delta_i V_x$	$\Delta^2_i V_{xh}$
0	—407.5	— 681.0	—273.5	.....
1	—416.5	— 705.0	—288.5	15.0
2	—421.5	— 740.0	—318.5	45.0
5	—424.5	— 890.5	—466.0	192.5
10	—425.5	— 990.0	—564.5	291.0
25	—427.0	—1043.5	—616.5	343.0
0	—417.0	— 691.0	—274.0	.....

*Potentials are copper-sulphate electrode" readings in millivolts.

Application to Buried Pipe Line

So far reference has been made only to a cylindrical conductor in an infinite conducting medium. Consideration of a buried pipe line leads to somewhat more complex algebraic expressions inasmuch as the conducting medium is no longer infinite, and for this reason the theoretical discussion, to retain clarity, was limited to the simpler mathematical forms. Practical application to buried pipe lines necessitates, however, the use of modified forms of the general equations, which for multiple pipe lines may become exceedingly complex and unwieldy. The following presentation, therefore, is limited to the case of a single pipe line.

Again referring to Fig. 1 in which are shown the surface of the ground and the dotted virtual image of the pipe line, it is seen that the potential, V_p, at any point p is no longer due solely to the pipe line at the distance r', but its value also depends upon the numerically equal potential of like sign of the image of the pipe at the distance r''. The separate potentials at p are additive and the value of V_p depends upon both the radial distances r' and

r'' shown in Fig. 1. Therefore, from equation (2):

$$V_p = C + \frac{i\rho}{2\pi}\ln r'r'' \quad . \quad . \quad . \quad (7)$$

If we now consider a point on the surface of the pipe on the line connecting the centers of the pipe and its image, then $r'' = 2h - a$ when $r' = a$, where (from Fig. 1) h is the sum of the soil cover, c, and the pipe radius, a, if the thickness, t, of the coating is ignored. Proceeding as in the development of equation (3), we find:

$$C = V_a - \frac{i\rho}{2\pi}\ln a(2h - a)$$

Now if x is any point on the vertical, measured downward from the ground surface, then, as $r' = h - x$ and $r'' = h + x$:

$$V_x = V_a + \frac{i\rho}{2\pi}\ln\frac{(h^2 - x^2)}{a(2h - a)} \quad (8)$$

Similarly, if in the test plane, x is any point on the surface of the ground measured from the vertical connecting the centers of the pipe and its image, then based on:

$r = r' = r''$, $r'r'' = r^2 = x^2 + h^2$, the following relationship may be derived:

$$V_x = V_a + \frac{i\rho}{2\pi}\ln\frac{(h^2 + x^2)}{a(2h - a)}. \quad (9)$$

Values of V_x in equations (8) and (9) may be plotted against the associated logarithms of the function of the purely geometrical quantities h, x, and a. All data will fall on a single straight line as, by inspection, the slopes of equations (8) and (9) are identical, the point, $\log h^2$, is common when x in both equations is zero, and both curves, when $V = V_a$, intercept the logarithmic axis at $\log a(2h - a)$. Considerable use of this relationship will be made later. An example of the identical collinearity of these equations has previously been given by the writer.[4]

The several potentials are identified by a subscript that serves to identify the geometrical point of reference. For example and again referring to Fig. 1, the potentials V_x, V_h, V_t, and V_a are, respectively, the potentials at some point x (usually in the test plane on the surface of the ground), at the important point h directly over the pipe where $x = 0$, (the coating surface), and nearly at the surface of the pipe.

Still referring to Fig. 1 the differences in potential (ΔV_{xh}, ΔV_{ht}, ΔV_{ha}, and ΔV_{ta}) identify the geometrical portions of the medium from which the differences in potential are derived. Strictly, the potential difference, ΔV_{ta}, is not purely geometrical but it has a geometrical equivalent.

If the potentials, V_x, and the potential differences ΔV_{xy}, are measured while a controllable external source of current (as in cathodic protection) is effective, then a prime sign is used to denote the fact; for example, V'_x and $\Delta V'_{xy}$.

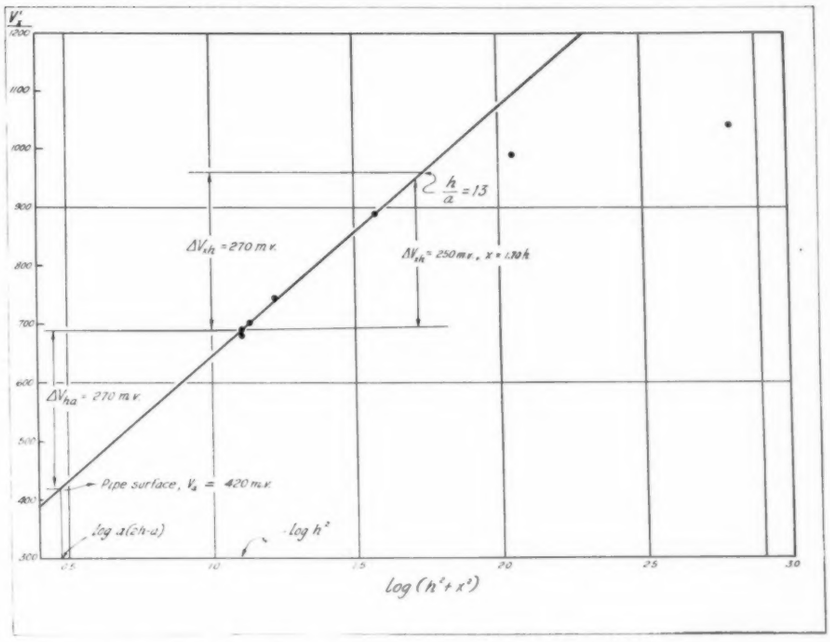


Fig. 2. A distribution of potential about a buried bare pipe line

From Fig. 1 it is obvious that in general $\Delta V_{xy} = V_x - V_y$ and that ΔV_{xy} may be obtained from measurements of V_x and V_y or ΔV_{xy} may be measured directly.

Now if the pipe line is covered with a thin conducting coating of thickness t and where the unit resistance $\rho' > \rho$, then there will be a drop in potential through the coating caused by the current i and the mentioned curves will no longer intercept the logarithmic axis at the point corresponding to $a(2h - a)$ when $V = V_a$. Inspection of equations (8) and (9) shows that as $a \doteq 0$*, $V \doteq \infty$, hence a coated pipe line would be expected to behave like a bare pipe line of smaller radius, a', as shown in Fig. 1. Similarly, if the resistance, ρ', of the medium immediately about the pipe is such that $\rho' < \rho$, then as $a \doteq \infty$, it follows that $V \doteq 0$ and the pipe behaves like a bare pipe in the limited environment of resistivity ρ' of larger radius a'. Accordingly we may define an "electrical radius" (a') of a pipe line as distinguished from the physical radius (a). Mathematically, $R_c\Delta V_{ta} = k\rho\Delta V_{aa'}$ where R_c is the coating resistance.

Obviously, therefore, to account for the coating, equations (8) and (9) and others may be rewritten in the more general form in which a is replaced by a'.

For example, from equation (9) we may now write:

$$V_x = V_a + \frac{i\rho}{2\pi}\ln\frac{h^2 + x^2}{a'(2h - a')}. \quad . \quad (10)$$

If we consider only the potential drop through the coating, then, as t is usually negligible with respect to a, from equations (6), (9), and (10), we obtain:

$$\frac{\Delta^2_i V_{aa'}}{\Delta i} = \frac{\rho}{2\pi}\ln\frac{a(2h - a)}{a'(2h - a')} = R_c \quad (11)$$

Substituting for R_c the conductance, C_c, in mhos per sq. ft., and solving for a':

$$a' = h \pm \sqrt{h^2 - \frac{a(2h - a)}{\log^{-1}(159/a\rho C_c)}}$$

. . . . . (12)

where h and a are now in inches.

Equation (12) relates the electrical radius of the pipe line to the conductance per sq. ft. of the coating. It is evident in this equation that as $C_c \doteq \infty$, $a' \doteq a$ and as $C \doteq 0$, $a' \doteq 0$.

The dependence of a' upon ρ is of interest. The physical significance of this dependency is that the coating of conductance, C_c, on the pipe may be replaced by a bare pipe of radius a' about which is a coating of thickness $a - a'$ and a conductance $1/\rho$. This, it will be recalled, is in accordance with the definition. Accordingly, the electrical radius of a pipe line having a coating of conductance C_c will in general vary as the resistivity of the conducting medium and in the direction of the variation of ρ inasmuch as for constant C_c, $a' \doteq 0$, as $\rho \doteq 0$.

Use of the Equations

In order to make good use of the theory it is necessary to know the re-

[4] "Application of the Potential Function to Problems in Cathodic Protection," by Gordon N. Scott. *Electrical News 10* (1), 43 (1940).

* $a \doteq 0$ denotes "a is approximately equal to, or approaches, zero."

sistivity of the soil. The soil unfortunately may vary to a considerable extent over very short intervals of space as has been amply demonstrated in numerous publications.[5] Furthermore, the soil varies in resistivity with depth even in soils of substantially uniform characteristics. There is usually no consistency in the variations in that different soils may show wide differences in the manner of the variation of the resistivity with depth. Also there is to be considered the seasonal variation in resistivity, which, in some soils at least, may be great.[6] Accordingly, the resistivity of the soil had best be determined at the time of the potential tests and at each subsequent test.

Although the Shepard earth resistivity meter may be used to good advantage for this purpose the writer has preferred the method of Wenner as this method may be adapted to determining an average of the soil resistivity about the pipe to the required depth.

The potentials, V_x, of a series of measurements in which x is varied may be plotted as ordinates against the common logarithms of the geometrical function $b^2 + x^2$ in equation (9). The resulting curve is a straight line as was shown and as has been amply proved in many practical cases by the writer in the reference[4] cited. The slope of the line is proportional to the strength of the current in the test plane entering or leaving the pipe and to the soil resistivity, namely:

$$\text{Slope} = \frac{2.303\, i\rho}{2\pi} \quad . \quad . \quad . \quad . \quad (13)$$

In cathodic protection we are usually interested in the current density per sq. ft. of pipe surface, $i_\square$, hence:

$$\text{Slope} = 0.0063\, i_\square\, \rho\, a \quad . \quad . \quad . \quad (14)$$

where the pipe radius, a, is in inches. The determination of $i_\square$ is about as far as we may conveniently go with equation (9) as we know relatively little about the components of V_a.

In Table 1 are given measurements on a bare 10¾-in. O.D. pipe line, with a soil cover of 37.4 in. The resistivity of the soil was found to be 3000 ohm-cm. The pipe line was to be cathodically protected but the measurements in the table were taken before any current had been applied to the line. In column 1 of the table is given the distance, x, in ft. measured on the surface of the ground from a point in the test plane directly over the pipe. The current was momentarily turned on and the readings V'_x were taken. Also recorded were the potentials V_x taken immediately after the current was turned off. These data, which are the averages of the measurements at equal values of x on both sides of the pipe line, are given in columns 3 and 2, respectively. The potentials in millivolts are referred to a "copper-sulphate" electrode at the several points x.

After the measurements at $x = 25$ ft. were completed the readings at $x = 0$ were checked, and it can be seen in the table that some polarization had occurred during the course of the test although the total time the current was "on" was exceedingly short.

The data in column 3, including the checked value at $x = 0$, are plotted as positive in Fig. 2 against log $(x^2+b^2.)$ It will be noted that the data for $x = 0$, 1, 2, and 5 conform well to the expected straight line that has been drawn through the four points mentioned. The calculated slope of the line is 426 whence the current density entering at the point of test is found by equation (14) to be approximately 4.2 milliamp. per sq. ft. of pipe surface.

At the pipe surface, corresponding to the abscissa, $\log a(2b - a)$, the potential reading is seen from the figure to be 420 mv., which is exactly the average of the entries in column 2, Table 1. Accordingly, $a' = a$ as would be expected inasmuch as the pipe is bare. We might have foreseen this possibility and thus had an additional point on the graph to assist in drawing the curve. But under some conditions rust scale may behave like a coating so this practice is not to be commended, especially when better means are available, as will be shown, for determining the slope of the line.

Now knowing V_a we may, if we choose, subtract therefrom the copper-sulphate electrode potential and thus have a measure of the true potential of the pipe with reference to its immediate environment entirely free of spurious potentials or *ir* drops, except that through the polarization film.

The above procedure where only V'_x is measured is objectionable in that the several values of V'_x may in some cases not differ greatly one from the other. Any two readings may be so large that differences between them cannot be accurately measured. Furthermore, if current is newly applied the readings may be affected by a change in V_a. In the field it is preferable, therefore, to only measure V'_b and the desired values of $\Delta V'_{xb}$ inasmuch as $V'_x = V'_b + \Delta V'_{xb}$.

Accordingly, we may use to advantage equation (4) in the applicable form, where the difference in potential is measured on the surface of the ground between b (where $x=0$) and x.

$$\Delta V_{xb} = 0.0063\, a\, i_\square\, \rho \log \frac{(b^2 + x^2)}{b^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

Values of ΔV_{xb} are measured between pairs of electrodes, one of which is positioned at $b(x = 0)$ and the other at various values of x. We may then plot ΔV_{xb} against the corresponding values of $(x^2 + b^2)$ on a logarithmic scale. The curve obviously will pass through log b^2, inasmuch as $\Delta V_{xb} = 0$ when $x = 0$. From the slope of the curve, $i_\square$ is calculated using equation (14). Thus the total current density at the time of test may be derived.

In practice the electrodes may vary somewhat in potential and as the current entering or leaving the pipe is usually different on either side of the pipe, four measurements are usually taken on the surface of the soil. The electrodes are first placed on one side of the pipe in one order and then interchanged and the procedure repeated on the other side of the pipe. ΔV_{xb} is then reported as the average of the four readings.

It has been shown[4] that under a wide variety of conditions the curves are linear within limits under most practical conditions; it is evident, therefore, that only a single ΔV_{xb} need be measured with the associated value of $x^2 + b^2$ as this value (having the coordinates $\Delta V_{xb} = 0$, $x^2 + b^2 = b^2$) serves to determine the slope of the line. Thus it is convenient to so fix x that the coefficient of the logarithmic function becomes some round figure and in this way save considerable labor in calculating the current when the data are voluminous. For example, from equation (15) where:

$$i_\square = \Delta V_{xb}/0.0063\, a\, \rho \log \frac{b^2 + x^2}{b^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

we may fix x in terms of b so that:

$$i_\square = \frac{50\, \Delta V_{xb}}{\rho} \quad . \quad . \quad . \quad . \quad . \quad (17)$$

whence, if $x = yb$, from equation (16):

$$y = \sqrt{\log^{-1} \frac{3.18}{a} - 1}$$

or more generally:

$$y = \sqrt{\log^{-1} \frac{159}{Aa} - 1} \quad . \quad . \quad (18)$$

where A is 50 but may be some other arbitrary number as well. For example in the case of the 10¾-in. O.D. pipe line referred to in Table 1 having a soil cover of 37.4 in., $a = 5.38$ in., and $b = 42.8$ in., we find from equation (18), that $y = 1.70$. If, therefore, the electrode is placed at $x = yb = 1.70 \times 42.8 = 73$, then from the measured difference in potential between this electrode and the one at $x = 0$ together with the known resistivity we may calculate the current density when the values are substituted in equation (17). Under these conditions ΔV_{xb} in Fig. 2 is 250 mv. Hence from equation (17), $i_\square = 50 \times 250/3000 = 4.2$ milliamp. per sq. ft.

Editor's Note: This article will be continued in an early issue.

[5] "A.P.I. Pipe Coating Tests," by Gordon N. Scott. *A.P.I. Proceedings 12*, (IV), 55 (1931). See charts.

[6] "The Seasonal Variation of Earth Resistivity Readings," by A. B. Allyne. *Proceedings Pacific Coast Gas Association*, p. 55, (1933).

PETROLEUM ENGINEER Exclusive Feature

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End Products of Cracking

Synopsis of Preceding Meetings

The first discussion involved a review of the various hydrocarbons and their thermodynamic qualities as related to the cracking of petroleum and its products. The main hydrocarbons in petroleum and its cracked products are paraffins, olefins, naphthenes, and aromatics. Of these, olefins are virtually nonexistent in most crude oils.

Points covered in the discussion included the following: (1) Chemical stability of compounds; (2) Relative crackability of hydrocarbons; (3) Energies released or absorbed in cracking; (4) The decomposition reactions, and (5) Effect of pressure on reactions.

In discussing the development of cracking, it was pointed out that the ability of petroleum to crack was discovered by the accidental overheating of a topping shell still, resulting in an unexpected straw-colored distillate, which was in reality cracked distillate.

Of the earlier cracking processes that followed the first patents on cracking granted to Young and Benton in 1865, the following were discussed: (1) the Benton unit; (2) the Burton-Clark unit; (3) the Coast still; (4) the Fleming still; (5) the Dubbs process; (6) the Isom process; (7) the Cross unit; (8) the Jenkins unit; (9) the Holmes-Manley unit; (10) the Winkler-Koch still, and (11) the Gyro vapor-phase unit.

The importance of clean recycle was first recognized when operators of earlier units discovered that clean stocks permitted longer runs with correspondingly small percentages of gas and coke formed.

In discussing the methods whereby maximum gasoline yield might be obtained by cracking, it was brought out that experience shows that a high reflux ratio results in a smaller yield of gas because of lighter cracking. It was decided to run to coke with as little gas formation as possible. If the residue is fuel oil there is bound to be some gasoline in this liquid product.

The equipment to be used to obtain maximum gasoline yield will be (1) a pipestill heater; (2) a reaction chamber to give the proper reaction time and to remove the coke, and (3) a fractionating tower to separate the gas and gasoline from the stock. Additional gasoline will be obtained if a multiple coil heater is used so that more rigid control from the fractionator will permit separate cracking from the various cuts at optimum conditions. Quenching will be essential to correct control of the time and temperature element.

The excessive heat brought to the fractionator from the reaction chamber can be disposed of in a number of ways: (1) the charge may be used as a quench; (2) heat can be exchanged with the charge to any adjacent unit, and (3) the remaining heat must be removed by reflux in the usual way.

In summarizing, the factors for higher gasoline yield are (1) higher reflux ratios; (2) time and temperature control for minimum coke and gas formation; (3) multiple coil heaters to obtain narrow boiling range cuts, and (4) run to coke rather than to any heavy liquid fuel.

If advantage is taken of all present-day developments in cracking it was decided that 75 percent gasoline yield was about the ultimate to be expected.

Class Meeting No. 5

Leader: We have said that time and temperature of cracking must be more or less worked out together. Well, is it more desirable to set a fixed temperature and work the time relationship out in accordance with that more or less arbitrary temperature, or is it best to work out an arbitrary time factor and then see where your temperature is?

Pupil: I have never had any experience with cracking, but offhand I would say you might assume some reasonable temperature and then if it developed that it would cost too much to maintain this temperature for too long a time, you might design for a little higher temperature and cut down the time.

Leader: What is the effect of increased temperature, or increased time?

Pupil: If you say the range in which we operate is from 900° to 1000°F. (482° to 538°C.), and if you increase the temperature 18 or 20°, you increase the rate of cracking a great deal; I believe you double it. That shows that a very small rise in temperature will effect a great change in the cracking time.

2nd Pupil: Do I understand you to mean that you double your cracking rate? Does that mean that you double the gasoline yield?

1st Pupil: No, but you would get more gas formed.

Leader: How can we know what our optimum—or our maximum gasoline yield can be?

Pupil: Ultimately I suppose it would depend on the number of times through with less crack per pass to cut down gas formed. I really don't know, except the less severe the cracking, then the less gas formation you have in general, and if you cut down on the temperature and severity of the cracking, you would cut down on gas formation and ultimately increase the gasoline yield.

Leader: All right, you have all submitted your ideas. Group A has worked out a two-coil cracker, with a coking chamber and two fractionating towers. Group B has worked out a single-coil cracking operation with coking. Is that correct? Group C has worked out a 2-coil cracking operation with 2 coking chambers and one fractionating tower. Group D has apparently worked out a 3-coil cracking operation with coking chamber and two fractionating towers.

Pupil: (group C) Group D did have 7 coils, I think, but they got cold feet.

2nd Pupil: We left six of those coils out finally to simplify matters.

Leader: Is the unit to make coke necessarily the way to make maximum gasoline yield? What substantiation is there for that belief?

Pupil: Fuel oil can be cracked until you can't crack it any further. If you have fuel oil left you can still get gasoline out of it by further cracking.

Leader: But isn't it true that the formation of coke is indicative of gas formation—high gas formation?

Pupil: Coke is a process of polymerization and condensation. If you could keep it from polymerizing, you wouldn't get that coke. You would have lighter hydrocarbons formed. Coking isn't always desirable—it just happens sometimes because you can't keep it from happening.

Leader: In the text (on p. 104) there is a rather interesting chart entitled, "The Composition of Synthetic Crudes Versus Time of Cracking." Just from an overall viewpoint, it would appear that the maximum gasoline yield was obtained before too much coke had been formed. That is the point that I am trying to raise.

Pupil: The formation of coke as carbon does signify gas formation but not necessarily the coke as we get it in the coking chambers. That is more or less a heavy hydrocarbon molecule.

2nd Pupil: How much free carbon is there in petroleum coke?

Leader: Is there a chemist in the class that will answer?

Pupil: I believe it is just a heavy hydrocarbon molecule, which is partly dehydrogenated.

2nd Pupil: If it is really good quality coke, it is fairly pure carbon. If it consists of hydrocarbon molecules, it is not desirable.

Leader: What is the percent soluble in carbon tetrachloride?

Pupil: I can tell you the percent soluble in benzol.

Leader: What is it?

Pupil: Usually under 1 percent, in top quality coke. The specifications on our coke are "under 5 percent."

Leader: What would be the carbon-hydrogen ratio in a good grade of petroleum coke?

Pupil: It would be very high, but I couldn't give you any figures.

2nd Pupil: Nelson gives tests on p. 146[1] in which the fixed carbon is between 80-90 percent.

Leader: I believe that should answer the question.

Pupil: It does form in the coke chamber as a tar though and not as a coke.

2nd Pupil: They blow steam through it as the chamber is full. Does that further remove hydrocarbon—or what happens then?

3rd Pupil: Steam is blown through the heavy tar after the still is shut down.

Pupil: What is the composition of the tar—is that greatly different from the coke?

2nd Pupil: I was going to ask whether the material in the reaction chamber when we shut down is fluid. Then the question arises, if we have fluid which is not pure carbon, and all we do is to steam it—do you think we get complete dehydrogenation from steaming?

3rd Pupil: I want to know what the purpose of steam and water is in the operation—that is, the second purpose.

4th Pupil: So far as I can see, the steam simply functions in compliance with laws of partial pressure and further distills the tar. The water is for cooling preparatory to the removal of the flanged heads.

2nd Pupil: I should like to cloud the issue some more. The vacuum unit produces tar and the yields formed are such that the ultimate yield on crude oil is about 6 percent. The yields of coke are such that the ultimate yield based on the crude oil volume is 8 percent.

Leader: That doesn't strike me as being particularly difficult.

Pupil: No, but it is interesting to know what happens to cause tar or coke to form.

Leader: It would appear to me that if the petroleum coke was 80 to 90 percent carbon that it is immaterial whether it is a heavy molecule of petroleum or whether it is pure carbon.

Pupil: I believe it is immaterial, but I do not agree that there is only 1 percent that is not pure carbon, or 5 or 10 or 20 percent.

Leader: If the analysis is 80 percent carbon, I don't see how we can deny its existence. That is, 80 to 90 percent carbon—just carbon and not fixed carbon.

Pupil: What is the analysis before they blow steam through coke in the chamber?

Leader: That is an interesting point, but I don't believe it is important in the analysis of this particular problem. I don't like to drop the discussion, but I don't see the objective in it.

Pupil: Well, I've got an objective.

2nd Pupil: The reason that I asked that question—after class the other evening someone asked me what happened there—if the pure carbon was a decomposition of the light gases like methane, and I told him I didn't think coke was formed in that manner, but rather is the result of condensation reaction of heavy hydrocarbons.

Pupil: One thing on that coke question: you can assume the formula for hydrocarbon products to be C_nH_n+2 and C_nH and by dropping H's on these heavy molecules you can obtain C_nH_2, let's say until you drop 100 H's. Even though you drop hydrogen atoms and keep the hydrocarbon atoms (without any hydrogen on them), you can have a very high hydrocarbon ratio and still have a hydrocarbon molecule that is not a pure carbon.

Leader: That's why I don't believe it is necessary to conclude we have pure carbon in our coke in order to analyze the problem.

Pupil: Sachanen[2] says, in talking about cracking coke, (from the second paragraph on p. 397): "Coke consists probably of highly polycyclic aromatic hydrocarbons very poor in hydrogen . . . the content of fixed carbon is 80 to 85 percent."

2nd Pupil: The best petroleum coke is formed by a severe distillation such as occurs in shell stills. The true petroleum coke as I understand it is an entirely different product from the coke produced from pressure-still operations.

Leader: My personal opinion is that the coke formed in pressure-still operation is not pure carbon, by any means. As to its being a liquid in the still and a solid out of the still, I think that is based on the fact that it is a hydrocarbon molecule with a very high melting point. Undoubtedly the addition of water in the chamber causes a considerable volume of light material to be distilled-off but even the material that is left is subject to melting. You can take ordinary petroleum coke and put it over a flame and it will melt, which would be proof enough that it is not pure carbon.

Pupil: Many people believe there is a high content of pure carbon in coke, but I have always understood it is a heavy molecule.

Leader: There is no question but what there is pure carbon in the coke.

Pupil: Take a sample of coke and ignite it, and you will observe a great loss (12 to 15 percent). The residue remaining would probably be almost entirely pure carbon.

Leader: Is everyone satisfied with the present discussion of coke?

Is pure carbon the result of destruction of methane to hydrogen and pure carbon or is it just dehydrogenation of heavy molecules or hydrocarbons? If it does have to go through methane in order to form pure carbon, then a high yield of carbon would surely mean a high yield of gas. That's the point that I am working on. That is the purpose of the present discussion.

Pupil: Isn't hydrogen sulphide a factor? After steaming-out the unit, can't you notice hydrogen sulphide gases around the blowdown sump?

Leader: That would be classed as an impurity.

Pupil: The steam removes the hydrogen from the tar and causes the high-carbon deposit.

Leader: That would be rather a far-fetched assumption. I mean that method of proof would take a lot more proof.

Pupil: Although it may be a little off the subject, I was recalling that when manufactured gas is formed through the destructive distillation of coal, you also get a coke formed that is very similar to petroleum coke formed in cracking. In addition to benzene, toluene, and xylene, heavy tar is also a product and that tar can be blown with air and reduced to coke. So I don't see why in a cracking still you have to assume that the fixed carbon comes from the complete destruction of methane to coke. When you crack a product, you do not speak of that as complete destructive distillation. It is decomposition and always during decomposition you have a certain amount of hydrogen formed.

Leader: Why is it important to know that?

Pupil: If the pure carbon in the coke is from methane, the methane must be formed before the carbon began to form. Obviously you would

[1] *Petroleum Refinery Engineering* by W. L. Nelson. Published by McGraw-Hill Book Company, Inc., New York, 1936.

[2] The text used by the class is *Conversion of Petroleum* by A. N. Sachanen. Published by Reinhold Publishing Corporation, 330 West 42nd St., New York, 1940.

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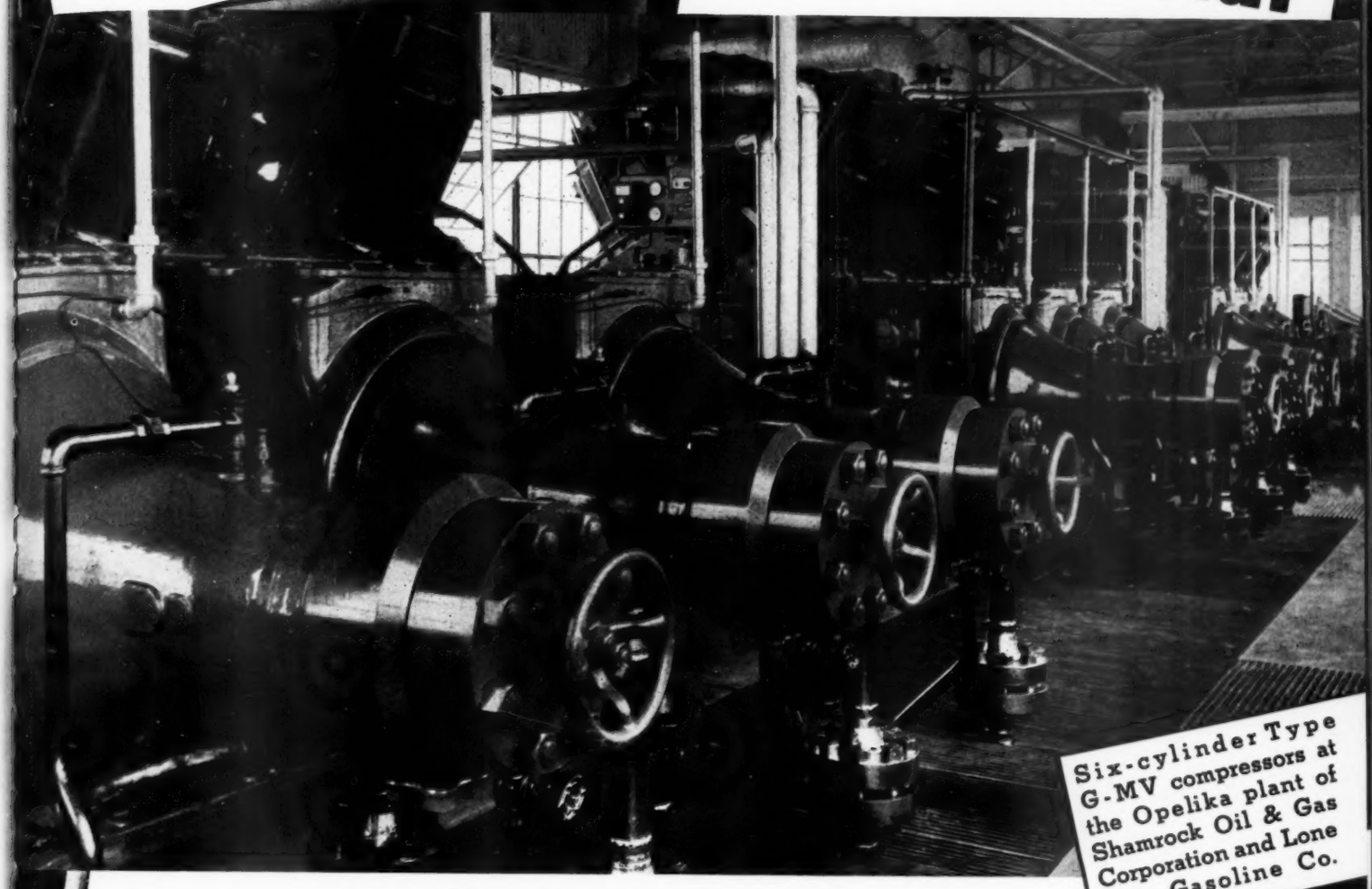

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have a higher yield of gas than if it did not go to pure carbon, but if it is just a molecule of heavy hydrocarbon that would have no bearing.

2nd Pupil: Sachanen makes the statement that complete cracking occurs when the hydrocarbons are reduced to pure hydrogen and coke. That would probably indicate that the coke might begin with methane, split-off the hydrogen, and part of it go to pure coke; however, if there is a large amount of gas in the product, it would probably have a high percentage of pure carbon in the coke.

3rd Pupil: That would be an indication of the percentage of gas given off.

Pupil: If methane is formed first, how can it be decomposed in ordinary cracking? It requires very severe conditions for any decomposition of methane to take place.

Leader: Are we right in concluding that the formation of coke is not due to the ultimate destruction of the hydrocarbon molecules, but is due principally to condensation? To be accurate, can we call it condensation, aromatization, and polymerization?

Pupil: Yes. All are involved, but condensation is particularly important.

Leader: I believe that clarifies that point. Let's get back to the original question. Does the formation of maximum gasoline volume necessarily occur with coke formation?

Pupil: It decreases on coke formation.

Leader: I am talking about maximum yield.

Pupil: You would say maximum gasoline comes with minimum coke formation, but the residue should go to coke. The objective is to make coke rather than fuel oil and to make a minimum amount of gas. You want gasoline and not gas and coke.

2nd Pupil: Maximum gasoline yield is tied-up with reducing the residue from the original charging stock to the smallest possible quantity and controlling the reactions to avoid overcracking and thus producing an excessive amount of gas. The residue of smallest volume would be coke.

3rd Pupil: Nelson says that the control point would be a heavy tar, which, when steamed, would produce a coke formation.

4th Pupil: Sachanen says that if you can successfully change the specific gravity from a low point to a high point and incur a minimum of varied reactions, that would be the way to get the maximum gasoline yield.

Leader: If we reduce the charging stock to a point where it has a large amount of carbon and a small amount of hydrogen, we don't care what we call it, do we?

Pupils: No.

Leader: On the other hand, if we are losing gases that could, under proper conditions, be combined with some of this high-carbon, low-hydrogen material, the combination would result in making more gasoline, wouldn't it? So what we have to do is to keep the gas content low and have a high carbon content in the residual stock—isn't that the objective? Because every molecule of gas under proper conditions could be combined with a molecule of tar to form gasoline.

Pupil: If you can decrease the volume of gas formed, it will reduce the size of the polymerization plant required.

Leader: Isn't it desirable in our operations to crack both the light and heavy materials in such a way as to reduce gas formation? Will someone describe the process designed by Group A?

Pupil: In Group A's plant, we have a 26° A.P.I. residuum charge and use 2 fractionating towers. We have a 2-coil furnace, using heavy and light oil circuits.

2nd Pupil: Where are you taking your charge? Through a closed coil outside?

1st Pupil: It runs through a closed coil in the two towers.

2nd Pupil: What percentage of the feed to the furnace would you anticipate going through each coil?

1st Pupil: A little more than half through the clean oil coil.

Leader: I note that Group B has a design in which only a single coil is used. What was the general theory of this?

Pupil: We were not interested so much in the maximum gasoline yield, but what the flow of the oils through the furnace would be. One coil is ample to illustrate the point.

Leader: I believe it would be interesting at this point to discuss some of the details of why we should use two coils in order to obtain a maximum gasoline yield. What is the reason two coils are used?

Pupil: With the cracking rate and velocity contemplated for the heavy oil, it was our idea that coke deposits would be almost entirely eliminated. We have shown 875°F. (468°C.) as the outlet temperature, which would compare with 930-940°F. (499-504°C.) on the Dubbs unit. Then on the recycle, which has eliminated the dirty portion of the charge, a temperature of 975°F. (524°C.) is reached, with high cracking rate and a relatively small coke deposit by using clean circulation. That was our reason for the second coil.

2nd Pupil: There is another point that should be discussed. I got off on a side track and had too high a cracking rate. One of the other men assumes 875°F. on the basis of 20 percent cracking in one pass through the dirty oil coil. On the basis of 30 percent which I used, the temperature would have to go to 910°F. (488°C.). Coke will begin forming after 20 percent cracking.

3rd Pupil: I should like to ask these fellows where they get these outlet temperatures—from experience or from calculations?

1st Pupil: They are purely empirical—insofar as setting the temperature is concerned.

4th Pupil: What have they done to assure a clean circulation through the light oil coil? Why do they think they can operate at 975°F. temperature?

1st Pupil: I don't know the basis for Group A's temperature assumption, but the temperature I adopted came from making the charts and plotting time against temperature and assuming there would be a certain amount of cracking. Then I determined how much time it would take for that amount of cracking to occur and calculated the average rate of flow through the tubes, keeping reasonable transfer rates. Higher temperatures should mean less tube investment, so long as we don't get into alloys, at least.

Leader: How can you get clean recycle stock without fractionation?

Pupil: There has been no fractionation and no clean-up. It was assumed there would be no carry-over from the coke chamber. That is the one thing you will have.

2nd Pupil: We hadn't thought of that—most of our thoughts were on the furnace heating curve.

Leader: A heating curve is really more of a simplified chart for the purpose of making certain calculations on the furnace. I would still like to discuss the clean recycle requirements, and reasons for more than one coil.

Pupil: Sachanen says the lighter the hydrocarbon, the more heat it will require to crack it. Consequently, if you have a clean cut by fractionation, that fraction can be subjected to its ideal cracking range. With only one coil, there would be a mixture of heavy and light hydrocarbons and if the heavy hydrocarbons do crack first you would have more gas formed and more coke formed, and less cracking of the light hydrocarbons. That is the principal reason for having more than one coil.

Leader: Is there any way you could determine the minimum amount of coke that should be formed for the maximum amount of gasoline?

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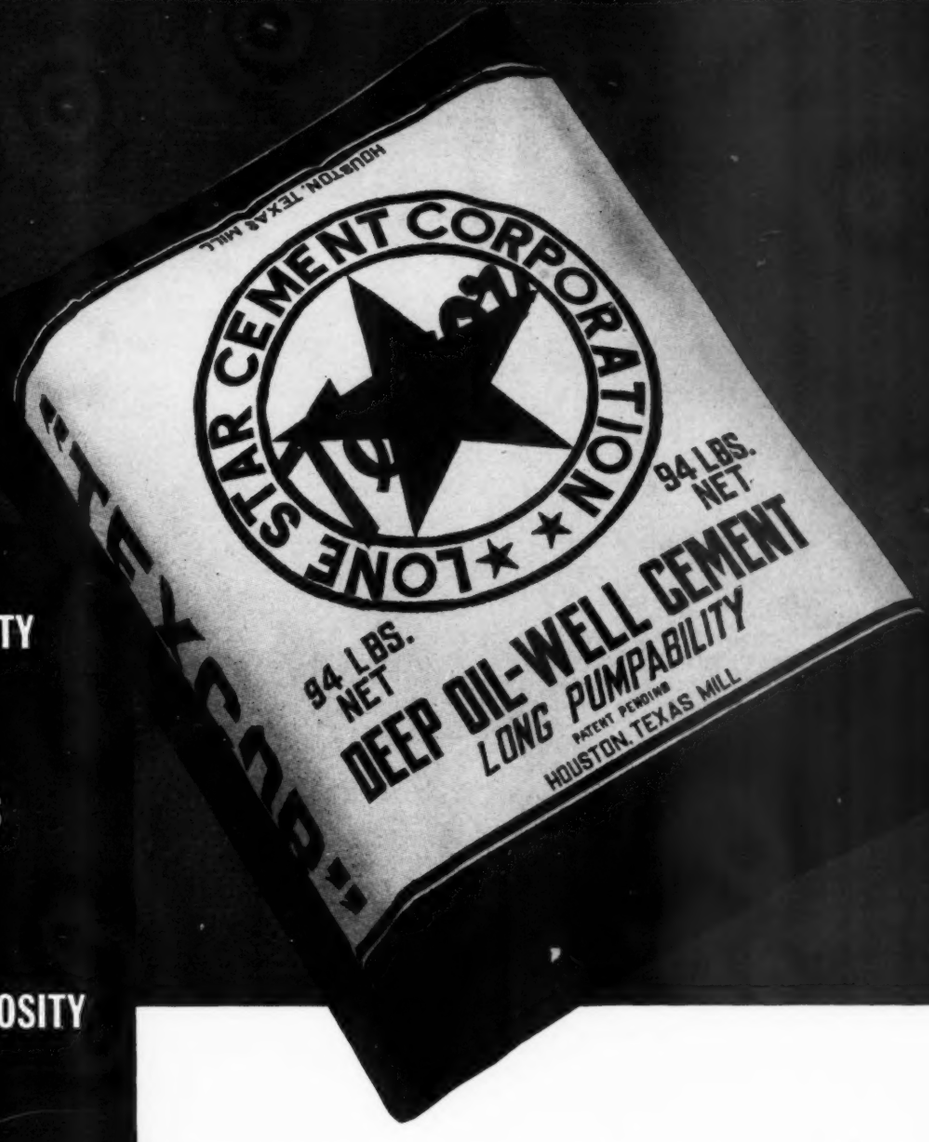

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Pupil: The investigator may have an air bomb into which the gasoline is placed. After maintaining a constant temperature and conducting the cracking for a certain specified time, the bomb is opened and the contents are analyzed. By calculating how much gasoline and gas are formed during a definite period of time, some idea of coking is gained.

2nd Pupil: Would you have to have a certain charging stock? Apparently, there would be a certain amount of coke regardless of the type of stock.

1st Pupil: There might not be any coke formed if perfect conditions could prevail. If polymerization could be prevented from occurring there should be no coke formed.

2nd Pupil: Isn't there some coke present before polymerization occurs?

Leader: I don't subscribe to the belief you would get no coke because of the ratio of the carbon to hydrogen in the charging stock and the ratio of hydrogen to carbon in the gasoline yield. If there is a high gasoline yield, it seems there would have to be some products formed that had a high carbon-to-hydrogen ratio.

Pupil: There might be enough olefinic hydrocarbons formed from the saturated hydrocarbons to keep the ratios in line, without coke.

2nd Pupil: But those olefins would polymerize and condense to coke.

Leader: That's what you want to prevent.

1st Pupil: Can polymerization be controlled accurately to prevent coke formation entirely?

2nd Pupil: Its control will go a long way toward preventing it.

3rd Pupil: Referring again to the formation of coke: if you were able to control the entire process—those heavy molecules could be gradually reduced and very little hydrogen would be produced. If entirely successful, the residue might be substantially pure carbon; at any rate the object of the entire operation is to attain the maximum amount of cracking with the minimum amount of coke formation. If you overcrack you will get too much coke and gas losses will be too high. So you get the maximum amount of gasoline produced from the dirty stock. With the recycle stock you have gone to such high temperatures for such a long period of time it would seem that you are over-cracking in the first pass but if you keep the temperature down you are not getting as much benefit from the third and fourth recycle passes.

Leader: That is a good point. When we cycle dirty oil through the heater, what determines the temperature at the outlet of the heater?

Pupil: It should be maintained low enough to avoid excessive condensation and gas formation.

Leader: Then the important considerations in determining the cracking reaction are the time and temperature through the reaction chamber. The total time and the corresponding temperature. Because at this point you will get a sudden rise in temperature—does the same thing hold true for your light oil coil?

Pupil: No, the light oil is quenched in the transfer line.

Leader: Cracking of the light oil must stop after leaving the coil but cracking of the heavy oil is carried on through the chamber. Isn't that right?

Pupil: Yes.

2nd Pupil: I don't agree that two coils are essential to a high gasoline yield—for quality I think they are.

Pupil: But you would have to conduct the operation to take care of the heaviest material. Cracking conditions are mild.

Leader: Then if you build up recycle—cracking under a milder condition you will come out with high gasoline yield and less gas formation. Is that right?

Pupil: It will constitute a vicious circle if you do.

3rd Pupil: If you figure the maximum gasoline cracking per pass, you can get the minimum coke formation desirable, and you will get a better grade product.

2nd Pupil: Better grade product but not a higher gasoline yield.

1st Pupil: The residuum charge will crack much easier than the recycle stock. If you heat both of them through the same coil, you will want to keep the time and temperature reduced to obtain the maximum gasoline yield expected on the residuum charge.

Leader: From a theoretical viewpoint, for maximum gasoline yield do you need to have all materials together or do you need to separate them?

Pupil: Separate them.

2nd Pupil: I believe you would have to separate them to eliminate the production of coke, if you figure the economics of the situation. If it were possible to build enough towers and furnaces, etc., I believe you could produce practically no coke.

Pupil: According to Sachanen in the text, there is a tendency for the molecule to split toward the middle and there is also a slight tendency to crack at the end. If you can keep the condensation down it will at least reduce coke formation. Sachanen says that if the product becomes lighter, it is harder to crack. That would reduce the gas formation at a given temperature, but it would not stop the condensation. If you have heavy and light stocks together, the heavy material might crack into 2 or 3 molecules. If it does that, overcracking will occur before any results are realized on the light materials.

Leader: I don't believe any of us are equipped to answer that argument tonight. We can probably get the answer, but it would take too much time, so I suggest that we all go ahead and read the text further. Rather than waste the time of the class, I think we will defer that point. Now, let us assume that we have a two-coil operation. How would we then regulate the quantities and temperatures of the material going through each of the coils? How would we arrive at those values?

Pupil: The arrangement shown in Fig. 10 met the situation.

Leader: In the equipment shown in Fig. 10, we were able to control the amount of material through each of the coils. Well, which of these coils would have the most going through it for maximum gasoline yield?

Pupil: For maximum yield, a larger volume necessarily would have to go through the clean-oil coil. Some of the heavier recycle stock would return through the residuum coil due to the fact that it would be so heavy that it would not flash-off overhead in the first tower.

Leader: Does everyone believe that there should be more material going through the light-oil coil than through the dark-oil coil?

Pupils: Yes.

Pupil: I think when you get right down to the question of doing it there is a doubt, inasmuch as you don't have too much control over the quantity of oil in the bottom of the first tower.

Leader: But we do have.

Pupil: Well, you do not necessarily know just how much is going out the top of the tower.

2nd Pupil: You can increase the temperature.

Leader: You can control it as much as you want to. You can control the amount you are going to have out the bottom of the second one, by the same method.

Pupil: Yes, that's right.

2nd Pupil: Then why wouldn't you on a 50-50 stream?

1st Pupil: That gets you right back in the argument we decided we would shelve.

Leader: Yes, that is right back.

Pupil: In connection with the volumes to be put through each coil, what assurance is there that you can go to the temperature you want? As the material taken off becomes lighter, it follows that it will be able to withstand increasingly higher temperature, doesn't it?

EDITOR'S NOTE: Proceedings of additional class meetings will appear in subsequent issues of *The Petroleum Engineer.*

ANNOUNCING

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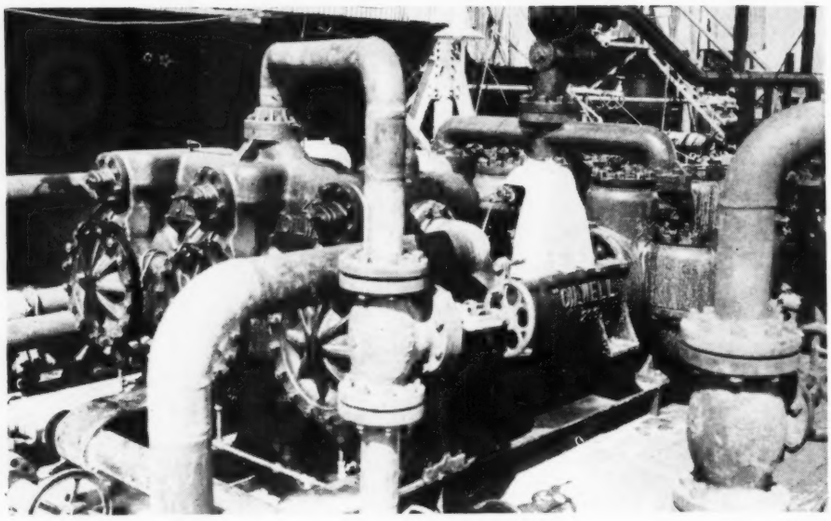
Showing the three steam cylinders of the new triplex pump



PETROLEUM ENGINEER Exclusive

by

Wallace A. Sawdon

Pacific Coast and Foreign Editor

Three-Cylinder Slush Pump For Deep-Hole Circulation

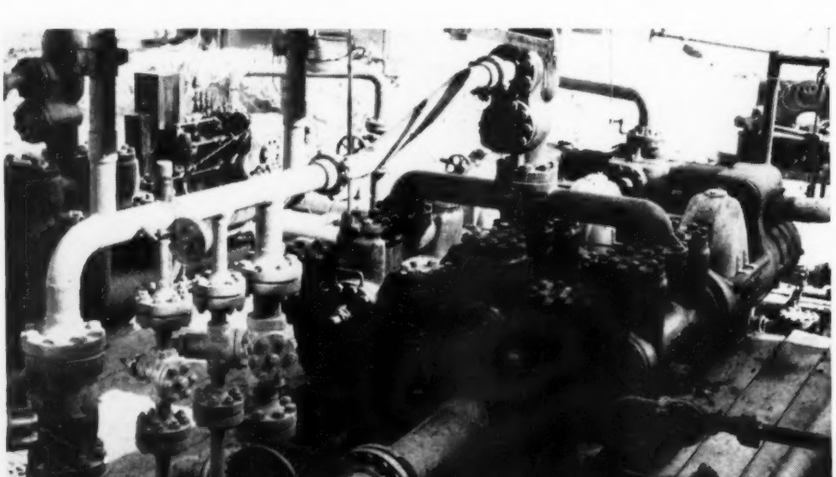
☆ Objectives of new pump are high-pressure delivery without compounding and large volume output with only one pump

ANOTHER advancement in equipment design to meet the requirements of deep drilling is a new 3-cylinder slush pump that has just completed its second well in one of the San Joaquin Valley fields of California. This pump was developed by Oil Well Supply Company and is to be known as the No. 320 Triplex Slush Pump. The one pump now in service is an 18-in. by 7-in. by 20-in. and although it has been employed for the drilling of only two wells to date, its use has supplied data that indicate the scope of its performance under operating conditions.

The primary objects of the 3-cylinder design are to provide for high pressures without compounding and to circulate a large volume of fluid with one pump. By using three cylinders there is also an overlapping of strokes and this is apparently the reason for the smooth action and elimination of pounding in operation.

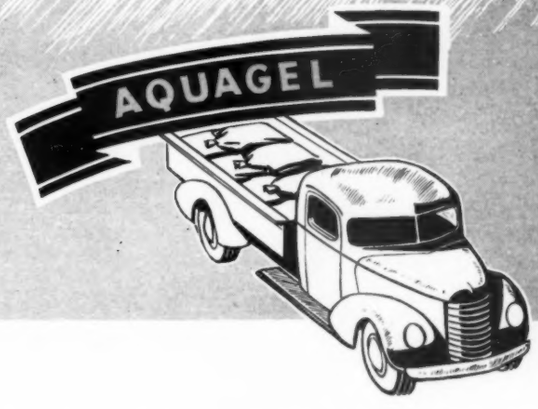
Although the pump is rated as having 7-in. cylinders, 7¼-in. liners can be used. In the two wells thus far drilled with the pump, however, only 6-in. liners have been employed. With liners of this size, circulating at a pressure of 2500 lb. per sq. in. and running at 48 r.p.m. (an r.p.m. being considered as a complete stroke forward and back) the calculated volume of fluid pumped was 640 gal. per min., based on operating conditions. When a 7-in. liner is used and the pump run at 50 r.p.m. with 300-lb. steam against a pressure of 2000 lb. per sq. in., the rated capacity is 930 gal. per min.

The liner is held in place with a heavy-duty roller bearing liner spacer specifically designed for high-pressure service. The spacer contacts the liner over the entire collar width to provide a uniform distribution of force and eliminate any movement of the liner that might result in cutting-out the liner or the fluid chamber. The spacer is centered on the liner by an external rim and the outer end fits the finished bore of the fluid chamber, thus preventing the spacer from being incorrectly located. One large-diameter adjusting screw extends through the cylinder head and permits tightening the liner from the outside without removing the head. A heavy-duty roller thrust bearing reduces friction and per-



Showing the mud manifold connecting to the three-cylinder pump

WHAT PRICE DRILLING MUD?



IN A 5000-FOOT WELL AS MANY AS 650 SACKS OF SOME NATIVE CLAY ARE USED IN FILTER CAKE ALONE; WITH AN AQUAGEL-WATER MUD, ONLY 18 SACKS!

Operators with an eye to economy as well as fewer drilling troubles use an AQUAGEL-water mud in place of ordinary native clay mud in wells which do not require weighted mud. On the basis of economy alone the saving is readily apparent by considering two open holes each 12¼" diameter and 5000' deep, one drilled with an ordinary native clay mud and the other with an AQUAGEL-water mud.

Some ordinary native clay muds deposit a filter cake ¾" thick. The total amount of such filter cake in a 5000' well will occupy a volume of 941 cubic feet made up of 45% by volume of solids (420 cubic feet of solids). At 2.5 specific gravity these solids will weigh 65,000 pounds and will use up 650 one-hundred-pound sacks of native clay for the filter cake alone.

AQUAGEL-water mud deposits a filter cake about ⅛" thick. The total amount of this filter cake in a 5000' well will occupy a volume of 165 cubic feet made up of 7% solids by volume (12 cubic feet of solids). At 2.5 specific gravity the weight of these solids will be 1800 pounds and will use up only 18 sacks of AQUAGEL for the filter cake.

Using these two muds as an example the tonnage required to build the filter cake alone on the walls of the hole is 35 times more in the case of the native mud than the AQUAGEL required. This extra unnecessary cake thickness is not only expensive but detrimental to drilling operations and may cause stuck tools.

For economy and safety use low-water-loss AQUAGEL-water mud, proved in oil fields throughout the world.

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BAROID and COLOX—Drilling Mud Weighting Materials.
AQUAGEL—Gel-Forming Colloidal Drilling Clay.
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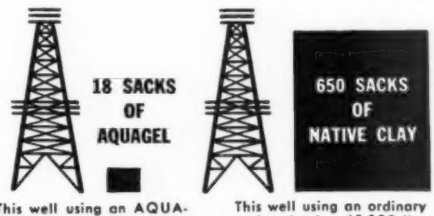

This well using an AQUAGEL-Water Mud has only 1800 lbs. of filter cake on the walls of the hole which is not only economical but very advantageous to drilling operations.

This well using an ordinary native clay has 65,000 lbs. of filter cake on the walls of the hole which is not only expensive but detrimental.

PATENT LICENSES unrestricted as to sources of supply of materials but on royalty bases, will be granted to responsible oil companies and operators to practice the inventions of any and/or all of United States Patents Nos. 1,575,944; 1,575,945; 1,807,082 and 1,991,637 and further improvements thereof. Applications for such licenses should be made to the Los Angeles office.

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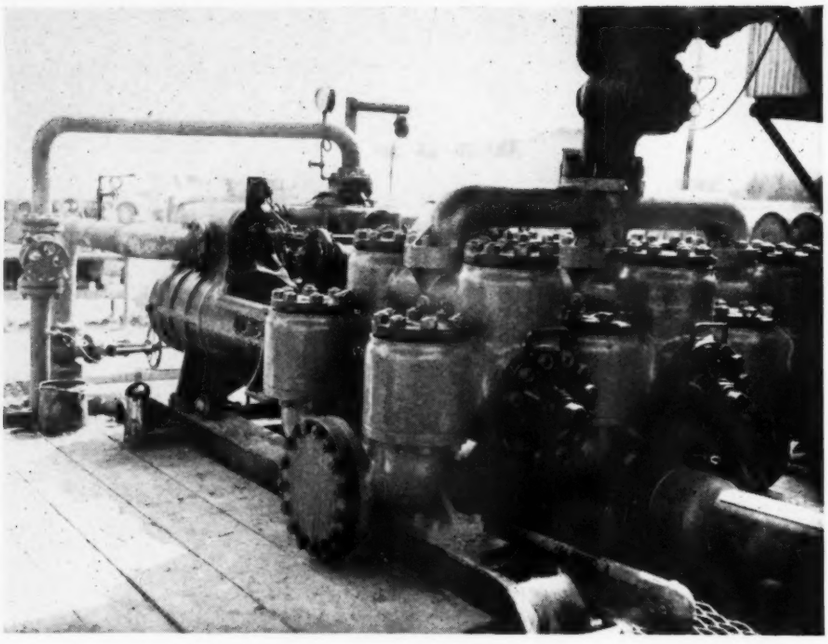

The three-cylinder pump occupies but little more space than a conventional duplex pump

mits free turning of the adjusting screw. A special packing ring in a groove of the cylinder head seals around the adjusting screw to prevent internal leakage on the discharge stroke or atmospheric leakage on the suction stroke.

The valve gear is equipped with needle-type roller bearings having oil seals and complete grease lubrication. The pump strokes out to full length regardless of pressure and speed. This has been observed on speeds as low as 25 r.p.m., the slowest the pump has been run in actual operation. The steam valves are of the piston valve type. The pump operates with a very short cushion yet the valve action is such that it never strikes the head. The fluid end is constructed of five parts: the suction manifold, the discharge manifold, and three cylinder castings. All three cylinder castings are identical, are accessible, and lightweight.

There has been no trouble in maintaining pressure in the boilers. The boiler plants used have consisted of 350-lb. superheated steam units but steam at the manifold has usually ranged from 250 to 300 lb. The pump has been able to circulate more fluid than could be used and the average speed has been approximately 40 r.p.m. At one time it was operated against a pressure of 2800 lb. per sq. in. at a speed of 40 to 45 r.p.m.

When drilling at 7700 ft. in the second well, the pump was circulating fluid at a pressure of 2350 lb. per sq. in. with 250-lb. steam at the manifold, the speed being 30 r.p.m. Hole was being drilled with a 6¾-in. bit on 3-in. drill pipe. At a speed of 30 r.p.m. the pump operated at 90 percent of stalling pressure. Slugs of air were easily worked out at various times during the drilling of the two wells.

P 111.391.

Potential Oil Area Disclosed in Southern South Dakota

DISCOVERY of a large anticlinal area, of possible interest to oil prospectors, lying between the Big Bend of the Missouri River and the Bijou hills, in south central South Dakota, has been revealed by the state geological survey at the University of South Dakota.

The discovery was made by a field party while investigating manganese deposits in the vicinity of Chamberlain, E. P. Rothrock, state geologist, announced. The structure includes parts of several townships and covers considerable territory that is worth prospecting, he said.

"Further interest is added to the region by the fact that some small showings of gas have been encountered in water wells in the district. Prospecting should not be expensive as the total depth of the sediments worth prospecting is estimated not to exceed 2500 ft."

Heading the field party that made the discovery were Dr. M. E. Wing of Beloit College, Wisconsin, and Dr. J. P. Gries of the South Dakota State School of Mines of Rapid City.

The state geological department's announcement is expected to intensify further interest in South Dakota oil prospecting. An estimated 8,000,000 acres are already under lease in North and South Dakota and much field work is planned for this summer both by major companies and independents. The new anticlinal area, however, is outside the region of South Dakota leasing activity, which is concentrated in the north central part of the state.

That much oil exploration activity is planned in South Dakota this summer was emphasized by the announcement of E. I. du Pont de Nemours and Company that a steel magazine is to be erected near Pierre for storage of dynamite to be used in exploratory work.

Seismograph crews that operated out of Pierre in 1939 and 1940 were supplied with explosives in small weekly shipments but a larger demand is anticipated this summer with several companies planning to operate crews out of Pierre.

The growing interest in South Dakota oil prospecting was also recognized by the state school and public lands department in the announcement that it is now prepared to grant 10-year oil and gas leases.

The leases will provide for an annual rental charge of 10 cents an acre for the first five years and 25 cents for the remainder. They will be signed only after being advertised for public auction.

The department now has 81,630 acres under oil and gas lease, producing a cash rental of more than $8,000. All leases provide for payment of one-eighth royalty.

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The ball has never washed out of a Larkin Float Shoe or a Larkin Float Collar during a cementing operation.

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Program Eleventh Mid-Year Meeting American Petroleum Institute . . . May 19-22, 1941 . . . Tulsa, Oklahoma

MONDAY THROUGH THURSDAY,
MAY 19 TO 22

COMMITTEE MEETINGS ALL DAY

WEDNESDAY, MAY 21

9:30 A.M.

DIVISION OF PRODUCTION

Drilling Practice—Mezzanine Floor—Junior Ball Room. (Sponsored by the Central Committee on Drilling and Production Practice.)

Papers on the following subjects will be presented:

"Pressure Core Analysis."

"Mud-Circulating Systems."

9:30 A.M.

DIVISION OF REFINING

Fuel Economy in Refining—Mezzanine Floor—Ivory Room.

"The Economics of Flue-Gas Recirculation and Economizers in Fired Tubular Heaters for Oil Refineries," by C. C. Nelson, Standard Oil Development Company, Elizabeth, New Jersey.

"Air Preheaters for Petroleum Heaters," by L. A. Mekler and H. A. Becker, Universal Oil Products Company, Chicago, Illinois.

"Generation of Steam as a Factor in Modern-Refinery Heat Economy," by W. W. Kraft, V. Mekler, and R. H. Riemenschneider, The Lummus Company, New York, New York.

"Fuel Economy in Refineries," by D. C. Lawrence, The Texas Company, New York, New York.

"Regenerative-Type Air Heaters for Refinery Use," by O. F. Campbell and T. B. Kimball, Sinclair Refining Company, East Chicago, Indiana.

12:15 P.M.

GENERAL SESSION—
LUNCHEON

General Session—16th Floor—Crystal Ball Room.

Address by Hon. Leon C. Phillips, Governor of Oklahoma, Oklahoma City, Oklahoma.

Address by Hon. Payne Ratner, Governor of Kansas, Topeka, Kansas.

2:30 P.M.

DIVISION OF REFINING

Corrosion of Refinery Equipment—Mezzanine Floor—Ivory Room.

"Water-Side Corrosion of Condensing Equipment," by B. B. Morton, Development and Research Division, International Nickel Company, Inc., New York, New York.

"Corrosion of Copper-Alloy Condenser Tubes by Water," by James T. Kemp, The American Brass Company, Waterbury, Connecticut.

"Water Treatment to Prevent Corrosion," by W. J. O'Connell, Wallace and Tiernan Products, Inc., Newark, New Jersey.

"Cathodic Protection of Open-Tank Condensers," by N. A. Miller, Universal Oil Products Company, Chicago, Illinois.

Corrosion Prevention on the Water Side of Refinery Equipment:

"Chemical Treatment of the Water," by W. H. Attwill, The Texas Company, Port Arthur, Texas.

"Use of Deaerator," by W. H. Attwill, The Texas Company, Port Arthur Texas.

"Cathodic Protection," by V. L. Nealy, The Texas Company, Houston, Texas.

"Chlorination of Condenser Waters," by D. R. Johnson, Continental Oil Company, Ponca City, Oklahoma.

"Deacidizing and Desalting Crude Oils," by G. B. Hanson, Petroleum Rectifying Company, Houston, Texas.

Pictures of Salt Separation.

6:00 P.M.

Complimentary Dinner—Coliseum.

THURSDAY, MAY 22

9:30 A.M.

DIVISION OF PRODUCTION

Production Practice—Mezzanine Floor—Junior Ball Room. (Sponsored by the Central Committee on Drilling and Production Practice.)

Papers on the following subjects will be presented:

"The Use of Depth-Pressure Data in Determination of Well Potentials in California."

"Chemical Treatment of Oil Sands for the Elimination of Water Blocks."

"Review of Gravel-Packing Methods."

9:30 A.M.

DIVISION OF REFINING

Fuels—Mezzanine Floor—Ivory Room.

"Evaluation of Diesel Fuels in Full-Scale Engines—Report of CFR Committee," by Walter Ainsley, Sinclair Refining Company, East Chicago, Indiana.

"1940 Road Detonation Tests—Compiled from Report of CFR Committee," by W. M. Holaday, Socony-Vacuum Oil Company, Inc., New York, New York.

"A.P.I. Motor-Fuel Research," by D. P. Barnard, IV, Standard Oil Company (Indiana), Chicago, Illinois.

2:00 P.M.

DIVISION OF PRODUCTION

Production Technology and Materials—Mezzanine Floor—Junior Ball Room. (Sponsored by the Central Committee on Drilling and Production Practice.)

Papers on the following subjects will be presented:

"Core-Analysis Interpretation."

"The Permeability of Porous Media to Liquids and Gases."

"Fatigue Effects in Roller Chain."

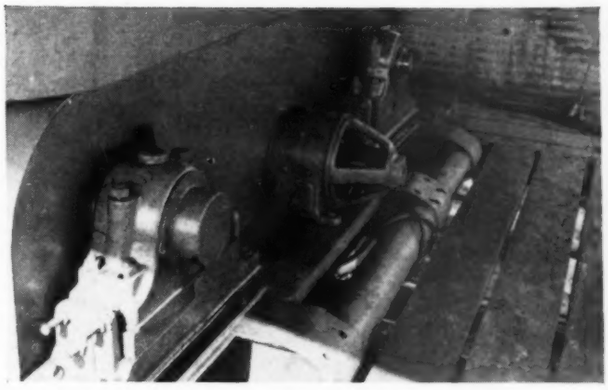
MONDAY THROUGH THURSDAY
May 19-22, Inclusive

GOLF TOURNAMENT

Southern Hills Country Club,
Tulsa, Oklahoma

(EDITOR'S NOTE: A.P.I. pictures may be found on pages 102 and 103 of this issue of *The Petroleum Engineer*.)

PETROLEUM ENGINEER Exclusive Feature



Ends of shafts and d-c. generator on transmission assembly

by
H. Lee Flood
Associate Editor

Two-Engine Drilling Rig Layout Achieves Flexibility In Streamline Arrangement

☆ Direct-drive to rotary table with six speeds available to drawworks or table are features of the design

THE increased use of high-speed internal-combustion engines as a source of power on drilling rigs has been accompanied by continually improved transmission layouts whereby two or more engines may be utilized singly or together to deliver power to the hoist, the table, and the pumps as needed. The general criterion has been to provide "as much flexibility as steam" and it has been to this objective that designers of power-driven[1] rigs have worked.

[1]The term "power-driven" has come into general use to denote the use of internal-combustion engines, whether the fuel used is gas, gasoline, butane, or Diesel oil. Often the term "engine-driven" is used. Both terms are confusing inasmuch as steam also involves the use of engines and steam is also "power". Despite the confusion, the man in the field generally makes himself understood and it is to the field terminology that this article adheres.

Many different ideas have been incorporated into the various engine and transmission layouts that have appeared in recent years. Many have achieved flexibility in engine operation but too often the design has resulted in unwieldly, extremely heavy parts that have been costly to buy and expensive to maintain.

The accompanying sketch shows the general layout of a rig that has only recently been placed in operation by one of the leading Mid-Continent drilling contractors. Designed by the contractor's chief engineer, the assembly serves as still another example of the aggressive manner in which drilling contractors attack their problems and often are responsible for many of the advancements in design and construction of drilling equipment that have been made so rapidly in recent years.

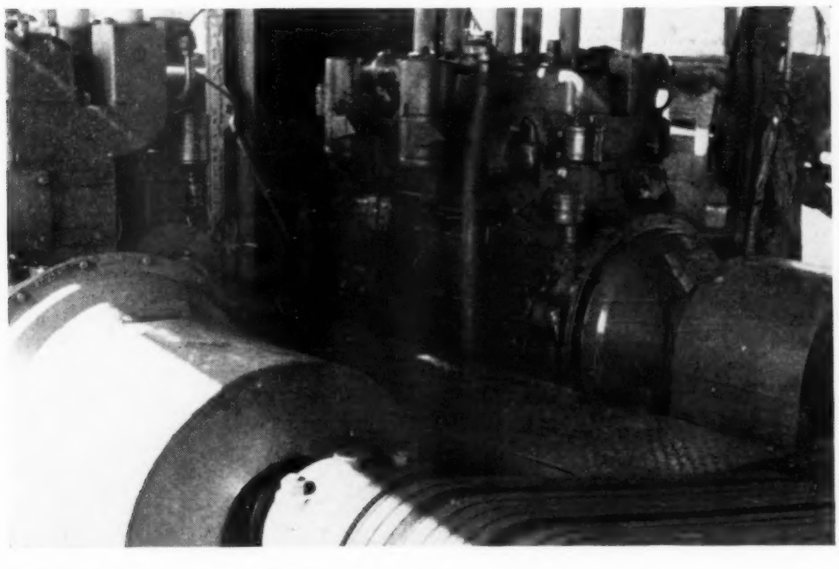
Two of the rigs are in use at the present time. One of them, at work in the Cumberland field near Durant, Oklahoma, has drilled two 5000-ft. wells and is now beginning its third well. Profiting by a study of the first rig's operation, the second assembly (incorporating a few additional features) has recently been completed and is now drilling its first well, a wildcat near Perry, Oklahoma.

Engine and Shafting Layout

Departing somewhat from usual design, the two engines are mounted side by side just back of the hoist with the crankshafts at right angles to the drumshaft of the hoist instead of parallel to it.

The driveshafts on both engines are each equipped with two V-belt pulleys. The pulleys farthest from the engines are joined by V-belts and serve to compound the engines when this is desired. The other pulley on the shaft of the right engine drives the mud pump. The other pulley on the shaft of the left engine drives the central shaft transmitting power to the drawworks and the rotary table.

On the central shaft a gear box situated just back of the drawworks serves as a takeoff for the shaft on which is attached the sprocket driving the hoist



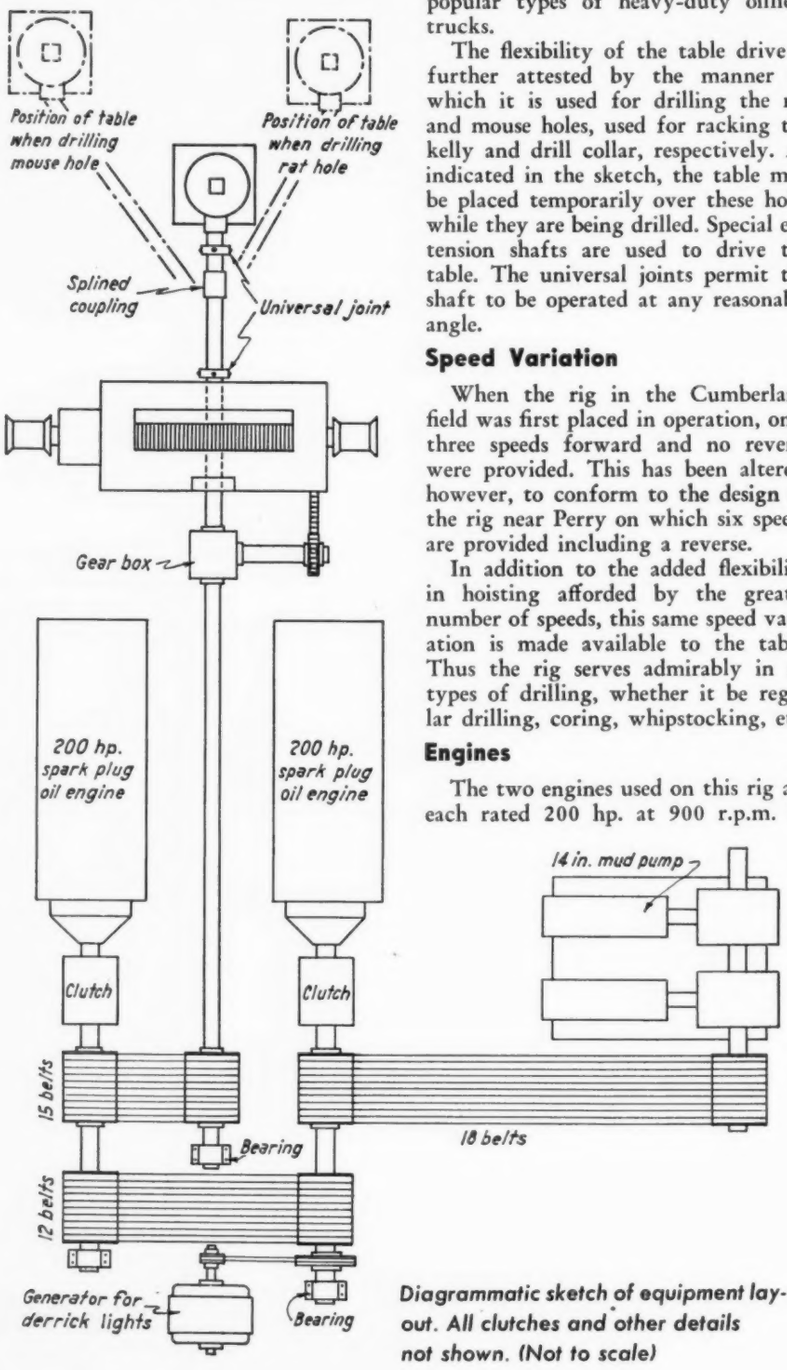
The two 200-hp. engines are mounted directly back of the drawworks

via a chain drive. The central shaft continues through the gear box and extends under the drum to the front side of the drawworks to serve as a direct drive for the rotary table.

A small d-c. generator mounted on the back member of the transmission framework is driven by V-belt from the right engine shaft. Lights when the engines are not running are supplied by a small-engine light plant.

Table Drive

The central shaft extends only far enough in front of the drawworks to permit a universal joint to be mounted.



Diagrammatic sketch of equipment layout. All clutches and other details not shown. (Not to scale)

On the rotary table shaft another universal joint is mounted and the removable driveshaft is flanged between the two universal joints. Mounted in the center of the driveshaft is a splined coupling that permits the length of the shaft to be shortened or lengthened approximately 6 in. The two universal joints and the splined coupling provide considerable flexibility in placing the table with respect to the drawworks. In fact, the table is usually higher or lower than the central shaft thus bringing the universal joints into play. The universal joints on the rig are the rugged type used in one of the popular types of heavy-duty oilfield trucks.

The flexibility of the table drive is further attested by the manner in which it is used for drilling the rat and mouse holes, used for racking the kelly and drill collar, respectively. As indicated in the sketch, the table may be placed temporarily over these holes while they are being drilled. Special extension shafts are used to drive the table. The universal joints permit the shaft to be operated at any reasonable angle.

Speed Variation

When the rig in the Cumberland field was first placed in operation, only three speeds forward and no reverse were provided. This has been altered, however, to conform to the design of the rig near Perry on which six speeds are provided including a reverse.

In addition to the added flexibility in hoisting afforded by the greater number of speeds, this same speed variation is made available to the table. Thus the rig serves admirably in all types of drilling, whether it be regular drilling, coring, whipstocking, etc.

Engines

The two engines used on this rig are each rated 200 hp. at 900 r.p.m. In normal operation, the engines are operated at 800 r.p.m.; consequently these engines should give long service with very little wear or strain.

The engines are of the spark-plug oil type, so that they may be operated as Diesels or fired by plugs.

The engines are equipped with air cleaners and provision is made for supplying lubrication to the upper parts of the cylinders.

Showing the universal joint (disconnected) at the base of the drawworks on the rotary table drive

Arrangement

The engines and transmission equipment are mounted on the same level as the derrick floor, 7 or 8 ft. aboveground. All controls are centered at the driller's stand, making it possible for the driller to control all operations without leaving the stand.

The one pump used on the Cumberland field rig is situated on the ground and is driven from the shaft above. Rated as a 7¼ by 14, the cylinder liner size of the pump is varied from 6¾ in. through the upper formations to 7½ in. during the deeper drilling.

All moving parts are adequately protected from the safety standpoint. The V-belt pulleys are covered during operation by a large hood. The central shaft is covered by a steel walkway that provides access to adjacent sides of the engines. The shaft to the table is covered by the platform on which the stands of drill pipe are racked when out of the hole.

SUPER STRENGTH

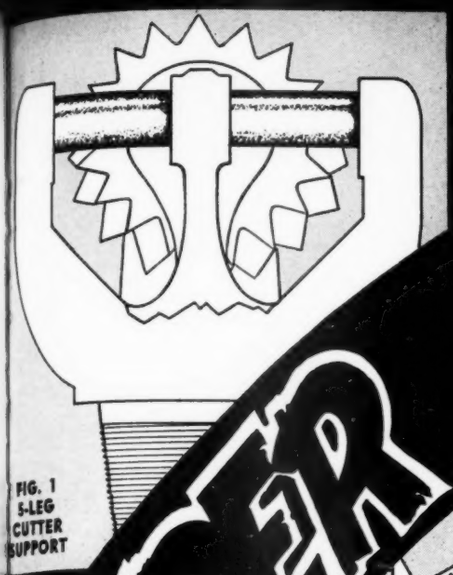


FIG. 1
5-LEG
CUTTER
SUPPORT

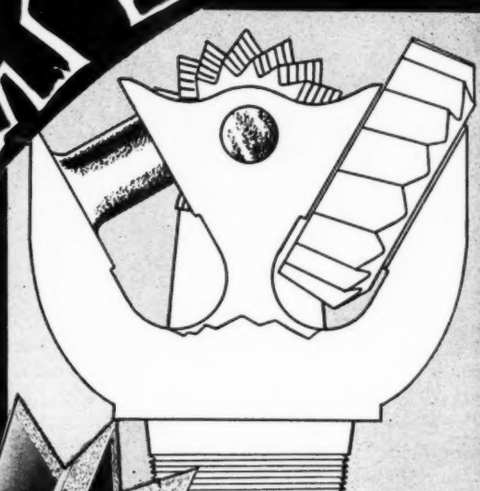


FIG. 2
SECTION
5-LEG
CUTTER
SUPPORT

HIGH CENTER

5 LEG CUTTER SUPPORT

As drillers well know, the extraordinary demands made on a rock bit necessitate constructional features that impart exceptional strength. In Globe Rock Bits this extra strength is obtained by the Globe patented 5th Leg, a reinforcement that holds cutter pins in exact alignment under severe twisting strains; prevents cutters from binding and running flat; reduces wear on bearings and pins; and prevents bit distortion under abnormal drilling loads. Figure 1. shows how the inner cutter pin is held firmly on both ends by legs and braced in the middle by the Center Support. Figure 2. illustrates how the gauge cutters rotate on pins supported by legs on the outside, and by the Center Support on the inside.

Additional Globe features are the Two-Way Inner Cutters (Figure 3.) which provide a double-action cutting surface which digs at opposite angles, and eliminates any tendency to track; and the Globe High Center (Figure 4.) design which insures straight hole. For detailed information regarding these and other advanced features of Globe Rock Bits, write for Catalog No. 41.

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P 629.2
P 773.35

Dehydration of Natural Gas and Absorption Oil

PETROLEUM ENGINEER Exclusive Feature

☆ Diethylene-glycol plant extracts water from natural gas — Gas bubbled through hot lean oil reduces water content of absorption medium

by C. S. Worley, Engineer, Consolidated Gas Utilities Corporation

and Dean E. Foster, Vice-President and General Manager, Bartlett Gasoline Company

DURING the last several years, in an endeavor to increase natural gas deliveries through pipe lines, many companies have increased operating pressure only to discover that actual deliveries at the higher pressures have been reduced. This has been due to the liberation of an additional quantity of water that collects in the sags or low places in the line, and to the accumulation of hydrates that seem to form rapidly as the water is agitated by gas through the restricted areas.

In order to forestall these conditions, many operating companies have installed dehydrating plants in or near the field to dry the gas. Several methods of dehydration have been tried, but the process employed most generally, perhaps, is the diethylene-glycol system.

Consolidated Gas Utilities Corporation found it advisable to make such an installation on its main transmission line in Wheeler County, Texas, during the summer of 1940, after preliminary tests had indicated the gas was carrying a moisture content of about 14 gal. per 1,000,000 cu. ft. As demand for delivery increased, it became evident that higher operating pressures would be required. Based on an analysis of the gas from this area, it was determined that the formation of hydrates would begin at a temperature of about 50°F. at the contemplated pressures.

The equipment and operating cycle employed in a diethylene-glycol dehydrating plant is quite similar to that used in the conventional type oil absorption gasoline plant.

The plant discussed in this article was designed to treat a maximum of 35,000 M. cu. ft. at a working pressure not in excess of 350 lb. per sq. in. gauge.

For these operating conditions, a 6-ft. by 18-ft. vertical absorber or contactor was considered adequate, with three bubble trays. The gas enters this contactor near the bottom and passes out at the top of the unit; the diethylene-glycol is forced in by a motor-driven triplex pump, entering near the top of the vessel. Passing countercurrent to the gas in the contactor, the spent glycol is trapped-off near the bottom. Passage of 7 gal. of glycol per min. at operating pressure and a temperature of 65°F. is sufficient to reduce the dewpoint of the gas from 68°F. to 30°F.

After the charged diethylene-glycol leaves the contactor, is passes through heat exchangers, and on to a 20-in. by 36-ft. still where the moisture is driven off in the form of steam, which is released at atmospheric pressure. The dehydrated glycol is then passed back through heat exchangers, then to water-cooled coils, and back to the triplex pump where the cycle begins over again.

C. S. WORLEY

attended the Engineering School of Oklahoma A. & M. College, Stillwater, 1902-1905—Began work in the oil and gas industry with the Henderson Gasoline Company, Nowata, Oklahoma, in 1914—Went with Jordan, Laney and Nickel, contracting engineers, Bartlesville, Oklahoma, in 1917—Organized firm of Worley, Johns and Bowman in 1919, operating in Kansas, Oklahoma, and Texas—Was assistant superintendent of the Gas Lift Department, Twin State Oil Company (Sun company), 1927 to May, 1929—Since June, 1929, has been an engineer for the Consolidated Gas Utilities Corporation, Oklahoma City, Oklahoma, being in charge of station construction and operation, and general engineering work—Is also purchasing agent for the company—Is registered as a professional engineer in Oklahoma and Texas—Member of Oklahoma Society of Professional Engineers, National Society of Professional Engineers, and National Association of Purchasing Agents.

DEAN E. FOSTER

attended Grinnell College for 3 years—Received degree of B.S. in mechanical engineering from Wisconsin University and M.S. from State College of Washington—Was research engineer for Cosden Petroleum Corporation, and consulting engineer specializing in design and construction of natural gasoline plants, compressor stations, refineries, reports and appraisals—Manufactured and sold Foster Baffle for packing absorption towers—Owner of Deer Creek Gasoline Plant—Organized Bartlett Gasoline Company, designed and built their Butler, Oklahoma, plant; is vice-president and general manager of company—Was co-organizer and first secretary of the Mid-Continent Section of A.S.M.E., and has been chairman of that body as well as section delegate—Representative American Engineering Council for six years.

ANNOUNCEMENT

Petrolite Corporation, Ltd. is the owner of the following United States Letters Patent relating to the resolution, demulsification, breaking, or treatment of petroleum emulsions, cut oil, roily oil, bottom settlings, basic sediment, BS, and the like:

1,531,173	1,656,622	1,766,064	1,897,575	1,977,146	2,025,805	2,077,229	2,104,794	2,166,434
1,555,818	1,656,623	1,766,065	1,902,129	1,978,227	2,026,195	2,077,230	2,104,795	2,167,346
1,570,987	1,659,993	1,766,066	1,908,129	1,979,347	2,026,217	2,077,745	2,106,239	2,167,347
1,590,617	1,659,994	1,766,067	1,908,130	1,984,633	2,026,218	2,077,746	2,106,240	2,167,348
1,595,455	1,659,995	1,766,112	1,910,680	1,985,692	2,026,219	2,078,652	2,106,241	2,167,349
1,595,456	1,659,996	1,771,096	1,913,538	1,985,720	2,034,941	2,078,653	2,106,242	2,171,328
1,595,457	1,659,997	1,773,517	1,926,715	1,988,832	2,034,963	2,078,654	2,106,243	2,176,702
1,596,585	1,659,998	1,780,343	1,929,399	1,988,833	2,037,885	2,078,655	2,106,244	2,176,703
1,596,586	1,659,999	1,780,344	1,938,322	1,988,834	2,037,886	2,079,762	2,108,960	2,176,704
1,596,587	1,660,000	1,780,345	1,938,323	1,988,835	2,050,923	2,079,763	2,108,961	2,183,487
1,596,588	1,666,001	1,802,090	1,940,390	1,990,293	2,050,924	2,079,764	2,110,837	2,192,993
1,596,589	1,660,002	1,812,393	1,940,391	1,994,758	2,050,925	2,081,003	2,110,846	2,192,994
1,596,590	1,660,003	1,829,205	1,940,392	2,000,717	2,050,926	2,081,004	2,110,847	2,192,995
1,596,591	1,660,004	1,834,940	1,940,393	2,000,725	2,050,927	2,081,005	2,110,848	2,225,824
1,596,592	1,660,005	1,837,130	1,940,394	2,000,802	2,050,928	2,083,220	2,110,849	2,226,118
1,596,593	1,710,159	1,842,934	1,940,395	2,015,260	2,050,929	2,083,221	2,114,651	2,226,120
1,596,594	1,727,164	1,858,186	1,940,396	2,023,976	2,050,930	2,083,222	2,122,976	2,226,121
1,596,595	1,727,165	1,863,143	1,940,397	2,023,979	2,052,281	2,083,223	2,126,368	2,226,122
1,596,596	1,747,119	1,872,286	1,940,398	2,023,980	2,052,282	2,083,224	2,127,905	2,226,123
1,596,597	1,747,987	1,872,333	1,943,815	2,023,981	2,052,283	2,083,225	2,153,744	2,231,752
1,596,598	1,758,802	1,873,165	1,944,021	2,023,982	2,052,284	2,085,298	2,153,745	2,231,753
1,597,700	1,766,057	1,882,444	1,954,585	2,023,993	2,058,568	2,085,299	2,153,746	2,231,754
1,606,698	1,766,058	1,890,789	1,961,963	2,023,994	2,058,569	2,086,215	2,154,422	2,231,755
1,617,737	1,766,059	1,890,849	1,975,839	2,023,995	2,058,570	2,086,216	2,154,423	2,231,756
1,617,738	1,766,060	1,897,019	1,976,602	2,023,996	2,072,085	2,086,217	2,166,431	2,231,757
1,617,739	1,766,061	1,897,021	1,977,048	2,023,997	2,076,623	2,089,035	2,166,432	2,231,758
1,639,325	1,766,062	1,897,574	1,977,089	2,025,804	2,076,624	2,104,793	2,166,433	2,231,759
1,641,804	1,766,063							

Chemical demulsifying agents for use in practicing the aforesaid patented inventions are manufactured and sold by Petrolite Corporation, Ltd. under the trade names "Tret-O-Lite" and "Dehydro".

Pursuant to the opinion of the United States Circuit Court of Appeals for the Ninth Circuit in Dehydrators, Ltd. et al. v. Petrolite Corporation, Ltd., 117 Fed. (2d) 183, Petrolite Corporation, Ltd. has fixed a royalty fee for the use of any or all of the aforesaid patented inventions at 20c per gallon ($10.00 per 50-gallon drum) of chemical demulsifying agent employed, whether obtained from Petrolite Corporation, Ltd., or from any other source.

A license is hereby granted to any one desiring to use the aforesaid patented inventions, conditioned only upon the payment of the aforesaid royalty. This license permits the user to employ any chemical demulsifying agent obtained from whatever source he desires.

Payment of the royalty shall be due within 30 days after the manufacture by, or shipment to, the user of the volume of chemical demulsifying agent involved. A cash discount of 2% is allowed if payment is made on or before the 20th day of the calendar month following the date of such manufacture or shipment.

Purchasers of the chemical reagents of Petrolite Corporation, Ltd. shall make payment to the office from which such royalties are invoiced. All other royalty payments may be made to Petrolite Corporation, Ltd. at 937 Pacific Avenue, Webster Groves, Missouri.

Any payment of such royalty shall not constitute an acknowledgment of the validity of any of the foregoing patents.

PETROLITE CORPORATION, LTD.

Approximately 15 boiler hp. is sufficient capacity for drying the diethylene-glycol.

After this plant was put into operation, it required about 30 days for the dry gas to pick up the accumulated moisture in the 60 miles of line between the dehydration plant and the Bartlett Gasoline Company's plant, which extracts gasoline from the gas.

Since this accumulation of moisture has been removed, the line capacity has been increased approximately 5 percent, due principally to removing the restrictions in the line where water deposits had accumulated.

Dehydration of Absorption Oil

After the gas is dried by the diethylene-glycol process described above, it passes through another compressor station at Carpenter, Oklahoma, thence flows about 15 miles before entering the Bartlett plant at Butler, Oklahoma.

In the normal operation of an oil absorption plant using the steam distillation process, the absorption oil retains a small amount of condensed steam. This amount varies from 0.05 to 0.20 percent, depending upon the type of oil used, the temperature of the oil from the still, the still pressure, the temperature of the process steam used, and its moisture content, if any, as it enters the still. As the water-laden absorption oil passes through the absorbers, its water content may be taken up by the gas. The gas entering the absorbers of the average plant will be saturated with water vapor at the temperature and pressure prevailing at the point of entrance. As it passes through the absorbers the gas will increase in temperature due to the heat liberated by the condensation and absorption of gasoline and lighter hydrocarbons. If the absorption oil has not been cooled sufficiently before entering the absorbers to offset this temperature rise due to absorption, the gas will leave the absorbers at a higher temperature than that at which it entered. At this higher temperature (and slightly lower pressure) the gas can hold more water vapor than it contained at the point of entrance. Consequently the gas will absorb enough water (if it is available) from the wet absorption oil to resaturate itself.

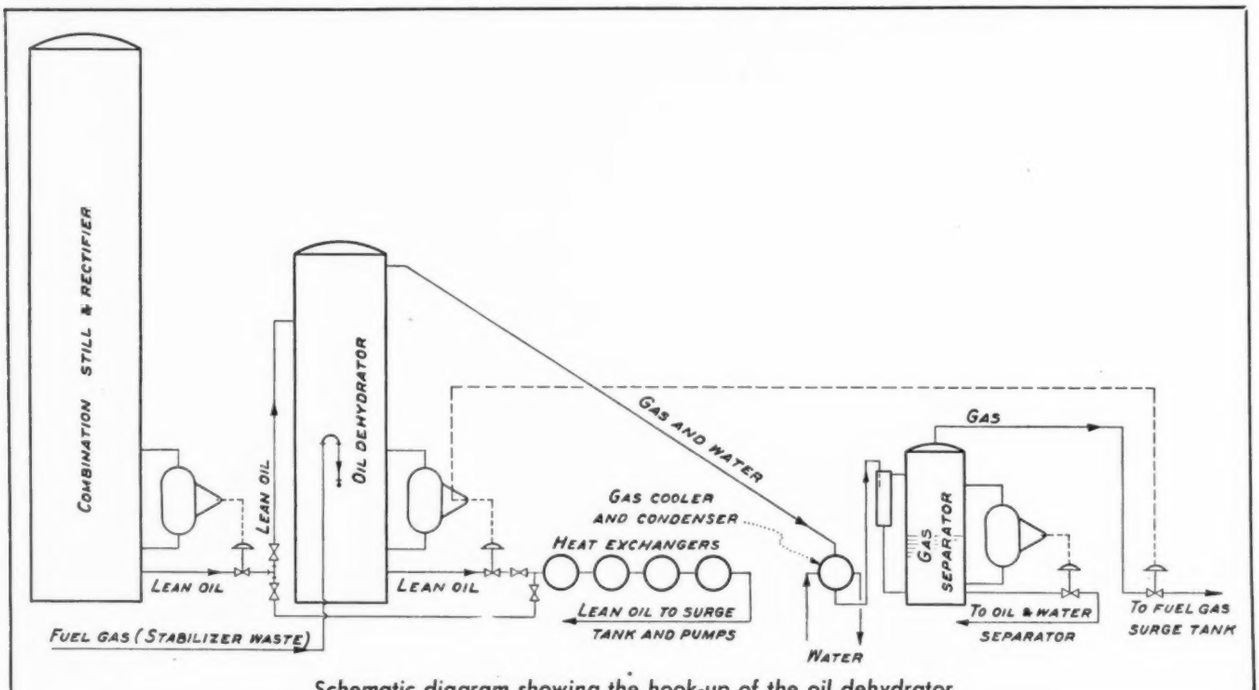
As it flows back into and down the pipe line, the gas cools to its original temperature and in doing so it condenses all the excess moisture absorbed at the gasoline plant. This moisture collects in the low spots of the pipeline system necessitating the installation of drips. Failure to install sufficient drips and thus keep the line clear of all liquid, will result in a reduction in pipe line capacity.

This is not the only objection, however, to saturating the gas with water vapor. The water condensed in the line will combine with the gas and form butyl, propyl, and other hydrates that collect on the pipe walls. This accumulation of hydrates gradually restricts the cross-sectional area of the pipe thus reducing its capacity still further. The temperature at which these hydrates will form depends upon the relative amounts of the various hydrocarbons making up the gas and the pressure existing in the pipe line. In an earlier paper[1], a chart was given in which is shown the relationship between pressure and temperature at which hydrates form for a large number of gases. This chart was accompanied by analyses of the various gases charted. By comparing the analysis of a given gas with the analyses of those cited by Deaton and Frost, one can estimated the hydrate formation point of a given gas with a fair degree of accuracy.

Absorption oil is not the only source of water as a contaminant of the residue gas. If the uncondensed steam still vapors are compressed to pipe-line pressure, then cooled and recycled through the main absorbers they will contribute to the resaturation of the treated gas. These vapors are saturated with water at still condenser outlet pressure and temperature. Upon compression to a higher pressure to recover additional gasoline and liquefied petroleum gases, these vapors will come to a new equilibrium and in doing so some of the water vapors coming from the still will condense, leaving the remaining gases saturated with water as they enter the absorbers.

Knowing the volume, pressure, and temperature of the recycle vapors, and the volume, pressure, temperature, and dewpoint of the incoming raw gas, one can easily calculate the amount of water added to the latter and its resultant dewpoint. Likewise, if one knew the amount of oil circulated and its water content, the effect of this water content could be calculated on

[1] "Gas Hydrates in Natural Gas Pipe Lines" by Wm. M. Deaton and E. M. Frost, Jr. Published in *Proceedings Natural Gas Department*, American Gas Association, 1937, pp. 23-31.



Schematic diagram showing the hook-up of the oil dehydrator

the outgoing stripped gas. Unfortunately, there is no generally known, simple test for the determination of the water content of absorption oil. The A.S.T.M. D95-30 test method will determine water contents above 0.1 percent, but is unreliable and inadequate for a water content less than this figure. It is employed by some companies for this purpose, and is useful above the limitation just mentioned. It was used a number of times at the Bartlett plant in testing lean oil samples taken from the cold end of the heat exchanger. In each and every case, however, it failed to indicate any water content.

The sources of resaturation of water having been determined, the problem of preventing resaturation or minimizing the increase in the dewpoint temperature of the treated gas resolves itself into reducing the water content of the fluids carrying water into the absorbers.

Reduction in water content of recycle vapors can be accomplished by increasing the efficiency of the recycle condensing system through the addition of more condenser surface if inadequate, or through the use of colder water that would call for changes or improvement of the cooling tower. If this should prove insufficient, refrigeration can be used to reduce the water content still further.

Several methods for reducing the water content of the absorption oil at the Bartlett plant were considered. The fact that comparatively cool unsaturated gas passing through the absorbers was picking up water from the cold oil suggested bubbling a small amount of gas through hot lean oil just after it left the still. After considerable inquiry it was found that two companies were using this method and obtaining satisfactory results therefrom. This idea was therefore adopted and a small bubble tower installed. The accompanying drawing illustrates the flow of oil from the still through the oil dehydrating bubble column thence into the heat exchanger. Calculations showed that very little gas would be needed and that there would be a negligible drop in oil temperature.

Tests made since this installation have definitely proved these facts. Fuel gas on its way from the stabilizer reflux accumulator to the boiler fuel header is passed through the bubble column thence to a condenser and accumulator separator where the water removed from the oil is trapped out with the small quantity of oil evaporated. These are piped to a separating tank from which point the oil reclaimed is drained into the surge tank on the pump suction. Tests have indicated that after a certain gas-to-oil ratio has been reached, no additional water is recovered but by increasing the volume of gas, more oil will be distilled. The gas-to-oil ratio is such that the fuel gas supply is sufficient in volume to dehydrate the oil and not too much in excess of requirements to necessitate bypassing any.

General layout of the equipment

At the time this was written, no test data on the residual quantity of water in the oil were available. Samples have been taken, however, and analyses are being run to determine how much this residue may be. The principles of physical chemistry indicate that there will be some residue. It would seem to be a fair conclusion, however, that if this residue cannot be reduced to zero by bubbling gas through the hot oil under low pressure, we should not expect cold gas bubbling through cold oil under pipe-line pressure to take up any. This statement is made with one reservation. Dewpoint tests of the fuel gas indicate that it contains some water vapor. This comes from the raw gasoline fed to the stabilizer. No calculations have been made to determine the effect of this water content upon the stripping efficiency of the fuel gas. Hence the conclusion stated above is open to some question. Tests to be run in the near future should determine its truth or falsity. If needed, suitable remedies are available.

Comparative tests to determine the difference in dehydrating efficiency of stabilizer waste or fuel gas and the stripped plant outlet gas indicated no difference in the amount of water removed, the same amount being recovered in each test for the same time interval and the same amount of oil circulated. The fuel gas was nearly saturated and the plant outlet gas had a dewpoint of about 40°F. at the time of the test.

Tests of the gas coming into the Bartlett plant have shown dewpoints ranging from 26° to 33°F. at pressures varying from 220 to 280 lb. per sq. in. An average over several weeks shows 257 lb. gauge pressure and a water content of 1.80 gal. per million cu. ft. For 24,000,000 cu. ft. per day, this represents a total incoming water content of 43.2 gal. If the temperature of the recycle vapors was held at 60°F. and their volume was 900,000 cu. ft. per day, the water content would be about 5.80 gal. per million cu. ft., or 5.2 gal. for 900,000 cu. ft. Adding these two water contents gives a total of 48.4 gal.

Assuming that no water is added to the outgoing gas by the absorption oil, and that there is a shrinkage of 450,000 cu. ft. due to gasoline production and fuel consumption, there would be 48.4 gal. of water in 23,550,000 cu. ft. of outgoing gas, or 2.07 gal. per million. This corresponds to a dewpoint of about 33°F.

All the calculations for moisture content were corrected for supercompressibility of the gas and fugacity of the liquid water.

These and other data gathered to date indicate that when all improvements have been completed, the results obtained should be quite satisfactory. It is needless to say that the difference in cost of these improvements to reduce the volume of water reëntering the gas and an installation to dry the gas represent a considerable saving.

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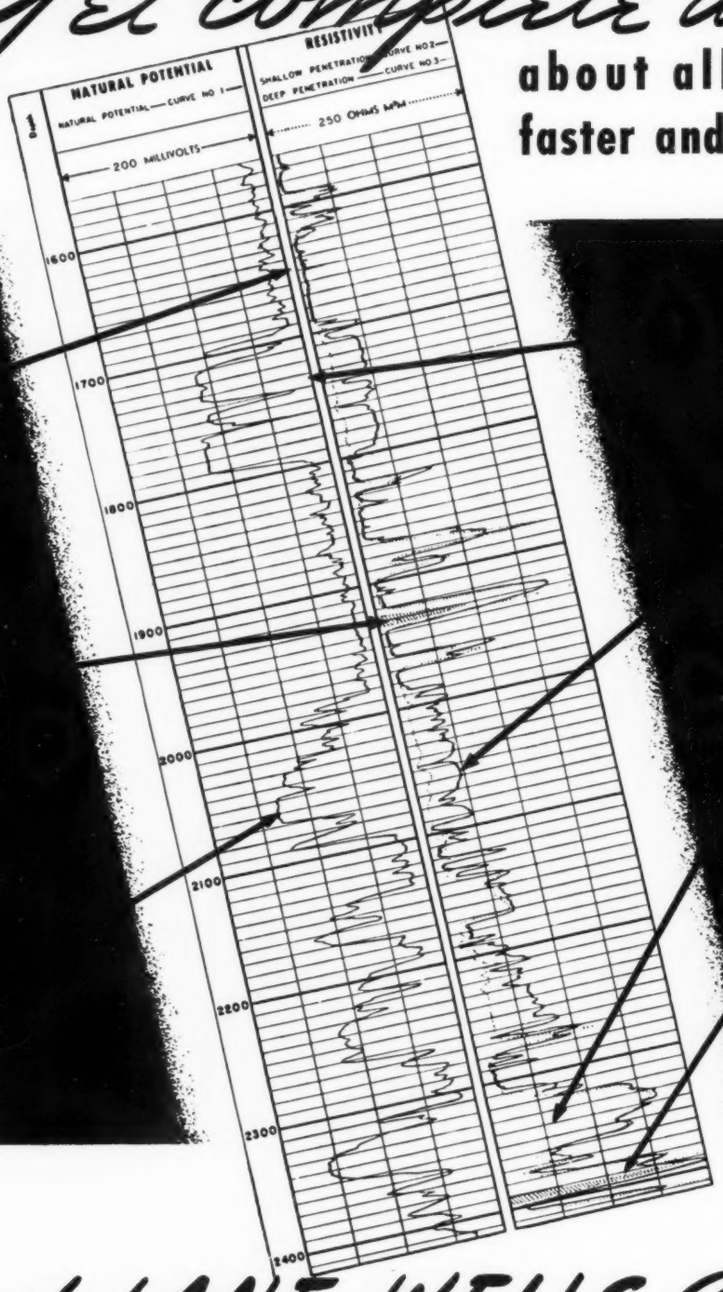

LOW NATURAL POTENTIAL; LOW RESISTIVITY indicates ordinary shale, clay, bentonite, or similar formations of low permeability, and high contents of trapped saline water.

LOW NATURAL POTENTIAL; HIGH RESISTIVITY of all Resistivity Curves indicates a dense formation of low permeability, low porosity, low fluid content, such as dense limestone, tight shale, hard shell, etc.

Natural Potential Curve, measures the self potentials existing between formations within the bore-hole.

HIGH NATURAL POTENTIAL; LOW RESISTIVITY on THIRD CURVE indicates a permeable sand containing salt water.

Shallow Penetration Resistivity Curve measures the resistivity of the formations close to the bore-hole, within the zone of drilling fluid invasion.

HIGH NATURAL POTENTIAL; HIGH RESISTIVITY on all Curves indicates a permeable sand or limestone containing oil, or gas.

Deep Penetration Resistivity Curves, Numbers 3 - 4, are lateral investigation curves measuring the resistivity of the formations back from the bore-hole and behind the zone of infiltration.

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Probability Theory Applied to Oil Exploitation Ventures

PART 4 (Concluded)

by Sylvain J. Pirson, Associate Professor of Petroleum and Natural Gas Engineering, The Pennsylvania State College

A photograph and biographical sketch of the writer can be found on page 27 of the February issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

Example 12: This example will deal with the same 40-acre lease assumed in Example 11 where a well located geologically is about to be drilled. If producing, the royalty on the property is estimated at $1000 per acre. Now, however, the speculator's available capital is only $10,000, which is a relatively small amount compared to the reward of $40,000 that he would receive if he bought the property and if the well became a producer. What is the break-even price that the speculator could safely give for the royalty before drilling commences?

We have found that the probability of a discovery by geology is $\frac{17}{125}$. Applying equation (26) we find:

$$x=\frac{10{,}000(10{,}000+40{,}000)}{10{,}000+\left(1-\frac{17}{125}\right)40{,}000}\left[\left(1+\frac{40{,}000}{10{,}000}\right)^{\frac{17}{125}}-1\right]=\$2749$$

It is, therefore, apparent that as the speculator's funds are further decreased, he can only afford to pay a smaller amount for a chance at the reward.

Example 13: A speculator is offered the purchase of the oil royalty of a 40-acre lease on a seismographic structure that is about to be drilled. The structure is determined by 5 stations at which the measurements are respectively 20, 25, 30, 35, and 40 ft. above the regional datum plane. Because of the difficult nature of the terrain it is estimated that the reflection seismograph is only accurate to ± 25 ft. It is also estimated that about one seismograph location out of ten good structures discovers a producing field. If the well becomes productive the present value of the lease per acre is estimated at $1000. What is the sum of money that the speculator may safely offer if he possesses an available capital of $10,000?

The reliability coefficient of the structure must first be calculated by means of equation (7). From Table 3, the values of y corresponding to the measurements in the order given above are respectively: 0.4237, 0.3173, 0.2301, 0.1615, and 0.1096. Therefore we have:

$$R=\frac{1}{10}\log_{10}\left(\frac{1}{0.4237\times 0.3173\times 0.2301\times 0.1615\times 0.1096}\right)=0.3261$$

Hence, the probability of discovering oil on this seismograph structure, which is equal to the product of the probability of discovering oil on a good structure multiplied by the reliability coefficient, is found to be: $\frac{1}{10}\times 0.3261 = 0.03261$. In other words, there are only slightly more than 3 chances in 100 that the well will be producing. Applying equation (26), we find the break-even value to be:

$$x=\frac{10{,}000(10{,}000+40{,}000)}{10{,}000+(1-0.03262)40{,}000}\left[\left(1+\frac{40{,}000}{10{,}000}\right)^{0.03261}-1\right]=\$545$$

Application to Producing Properties

The customary procedure followed in valuation of producing properties is to calculate the present value of the profits to be made and received in future years. Normally, it is not assumed that the excess profit over the expected speculative rate of interest will be reinvested at a safe compound rate of interest in such manner as to reconstitute the original capital at the expiration of the economic life of the property. Yet, it is proposed to show that such a procedure is advisable by using the example of a producing property on which the average composite decline curve is shown.

Example 14: A producing lease having 10 wells is fully equipped. The production has settled to a point where the future production can be estimated by the computation of an average composite decline curve and the prediction for future gross production is according to the second column of Table 5 in bbl. per year. One-eighth royalty is to be paid and the operating expenses per well are estimated at $2500 per year. Each well will have a salvage value of $3000 at the end of the producing life. The future price of oil is estimated to average approximately $1.90 per bbl. during the economic life of the field. The property is to be evaluated by using a straight discount factor of 10 percent compounded annually, which is the desired speculative rate of interest. The excess profit is not to be reinvested at a safe rate of interest. What is the present value of the property?

The economic limit of the field must first be calculated by dividing the costs of yearly operation, $2500, by $1.90, which gives 1316 bbl., and taking the royalty payments into account, the economic limit is given by $1316\times 8/7 = 1504$ bbl. Therefore, production will be stopped after 8 years.

Table 5 gives a summary of the computations for estimating the present value of the property.

The present value, therefore, of all ten wells is $630,136.10. To this figure must be added the present salvage value of the ten wells or $\$30{,}000\times 0.46651 = 13{,}995.30$ making a grand total of $644,131.40.

The solution of the problem as given in Example 14 is not quite justified because the large sums of money that are received during the first years can be invested at a safe rate of interest such as in bonds, preferred stocks, etc., and, therefore, contribute toward the reconstitution of the invested capital at the expiration of the enterprise. This would call for the application of the well-known Hoskold principle generally used in evaluating mining ventures. But, contrary to a mining enterprise, an oil field decreases in productivity each year and a constant rate of

(Continued on Page 56)

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TABLE 5

Present value of an oil property (straight discount) per well

Years	Gross production, bbl. per yr.	Net production, bbl. per. yr.	Price per bbl., dollars	Gross income, dollars	Operating expense, dollars	Net income, dollars	Discount factor $\frac{1}{(1+.10)^n}$	Present value, dollars
1	20,000	17,500.0	1.90	33,250.00	2500	30,750.00	.90909	27,954.52
2	13,200	11,550.0	1.90	21,945.00	2500	19,445.00	.82645	16,070.32
3	8,700	7,612.5	1.90	14,463.75	2500	11,963.75	.75131	8,988.48
4	6,000	5,250.0	1.90	9,975.00	2500	7,475.00	.68301	5,105.50
5	4,200	3,675.0	1.90	6,982.50	2500	4,482.50	.62092	2,783.27
6	3,000	2,625.0	1.90	4,987.50	2500	2,487.50	.56447	1,404.12
7	2,200	1,925.0	1.90	3,657.50	2500	1,157.50	.51316	593.98
8	1,650	1,443.75	1.90	2,743.13	2500	243.13	.46651	113.42
Total present value of one well								63,013.61

(Continued from Page 53)

return cannot be assumed. The present value of each yearly return must, therefore, be computed individually. If N is the net profit to be received during the nth year after the purchase of the oil venture when it is estimated that the oil reservoir will be exhausted after the mth year has expired, we can calculate what the present value (P.V.) of N should be in order to provide the investor with a speculative rate of interest r^1 per year and a safe rate r per year on the reinvested excess dividend.

The excess dividend, during the nth year is $N - (\text{P.V.})\left[(1+r^1)^n - 1\right]$

If this sum is reinvested at r rate of interest for the remaining period of $(m-n)$ years before exhaustion, the original capital corresponding to N must be reconstituted. Therefore we have:

$$\left(N - (\text{P.V.})\left[(1+r^1)^n - 1\right]\right) \times (1+r)^{m-n} = \text{P.V.} \quad . \quad . \quad . \quad . \quad (27)$$

Taking the value of P.V. out of (27) we have:

$$\text{P.V.} = \frac{N}{\frac{1}{(1+r)^{m-n}}\left[(1+r^1)^n - 1\right]} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (28)$$

To find out the difference in the present value occasioned by introducing the Hoskold principle, we shall apply equation (28) to Example 14.

Example 15. Assuming the property studied in Example 14 where the excess dividend is reinvested at the safe rate of 3 percent per year and a speculative rate of 10 percent is desired on the investment, what is the present value of the property?

The symbols of equation (28) take the following values: $m=8$, $r=0.03$, $r^1=0.10$ and N is the net income column. m varies from 1 to 8 and $m-n$ from 7 to 0. The problem can be solved best by means of the tabulation given in Table 6.

Therefore, the present value of the ten wells is \$728,956.80, to which figure must be added the present salvage value of the 10 wells or:

$$10 \times \$3000 \times \frac{1}{2.14360} = \$13,995.15,$$

making a grand total of \$742,951.95 or nearly \$100,000 more than when the Hoskold principle of reinvestment of the excess dividend is not used.

The preceding valuations are made on the assumption of a safe business venture, free from hazards of any kind, but any business man knows that when he enters into an oil-producing venture there is usually a certain amount of risk connected with it. The possibility of each of the several hazards should be evaluated separately and the effect on the possible value of an enterprise should be computed. By way of example, let us say that a particular hazard is estimated to have a probability of occurrence p and if it happens will multiply the value of the enterprise by a factor q, smaller than 1 if due to an unfavorable hazard and larger than 1 if due to a favorable hazard. If it is estimated that the value of the enterprise is A without the possibility of hazard, the mathematical value of the expectation is:

$$E = (1-p)A + pqA = A[1-p(1-q)] \quad . \quad . \quad . \quad . \quad (29)$$

If several hazards are now possible and their probabilities of occurrence are $p_1, p_2, p_3 \ldots$ giving respectively a coefficient of beneficiation or depreciation of $q_1, q_2, q_3 \ldots\ldots$, the mathematical value of the expectation becomes:

$$E = A[1-p_1(1-q_1)][1-p_2(1-q_2)][1-p_3(1-q_3)] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (30)$$

or more simply:

$$E = A\pi_{i=1}^{n}\left[1-p_i(1-q_i)\right] \quad . \quad (31)$$

where π symbolically represents the products of n factors and where n is the number of hazards to which the enterprise may be submitted.

The application of the theory of probability to valuation of oil properties is indicated in the following example.

Example 16: Assuming the property studied in Example 15 and using the Hoskold principle of valuation, the probability that the oil field will be drowned-out by water encroachment is estimated to be $\frac{1}{10}$; consequently the value of the property will be reduced by 10 percent. It is also assumed that due to social unrest, the probability that wages will be increased is $\frac{1}{10}$ and if so the value of the property will be reduced by 5 percent and finally it is estimated that the probability that a deeper producing horizon will be discovered is $\frac{1}{10}$ and if so that the value of the property will be increased by 25 percent. What is the mathematical value of the expectations?

As the present value of the property is \$742,951.95, according to Example 15, applying equation (31) we have:

$$E = \$742,951.95 \times [1-0.1(1-0.9)][1-0.1(1-0.95)][1-0.1(1-1.25)] = \$750,158.58$$

It is seen, therefore, that the possibility of the hazards mentioned has not greatly affected the mathematical value of the expectation, due to the possibility of compensating hazards.

Conclusions

The problem of applying the theory of probability to the business of discovering new fields has been reviewed as well as the method of giving weight to possible hazards in the valuation of producing oil properties. An application of the theory of probability in order to calculate the odds against discovering oil by geochemical prospecting has also been made and the problem approached from various angles. The problem of the reliability of a discovered structure is also treated and examples of calculations are given.

TABLE 6

Years	m-n	N = net income, dollars	$S = \frac{1}{(1+r)^{m-n}}$	$T = (1+r^1)^1 - 1$	U = S+T	$\text{P.V.} = \frac{N}{U}$
1	7	30,750.00	0.81309	0.1000	0.91309	33,676.85
2	6	19,445.00	0.83748	0.2100	1.04748	18,563.60
3	5	11,963.75	0.86261	0.3310	1.19361	10,023.16
4	4	7,475.00	0.88849	0.4641	1.35259	5,526.43
5	3	4,482.50	0.91514	0.6105	1.52564	2,938.11
6	2	2,487.50	0.94260	0.7716	1.71420	1,451.11
7	1	1,157.50	0.97087	0.9487	1.91957	603.00
8	0	243.13	1.00000	1.1436	2.14360	113.42
					Total.....	$72,895.68

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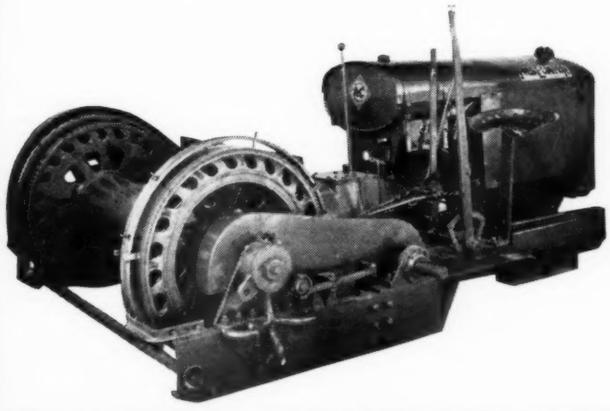

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A Functional Analysis of the Engineer's Place in the Petroleum Industry

PETROLEUM ENGINEER Exclusive Feature

PART 3

by E. N. Kemler, Associate Professor of Mechanical Engineering, Purdue University

A photograph and biographical sketch of the writer can be found on page 27 of the March issue of *The Petroleum Engineer*, in connection with Part 1 of this series.

IN SOME cases equipment selection may be greatly influenced by such factors as proration, casing size, expected reserves, local operating problems, local production practices, etc. In almost every case, however, some information on the individual well performance is necessary in arriving either at the equipment requirements or at what might be expected at any period in the life of the well by the use of a particular size of equipment.

Once the equipment has been selected and the proper size determined the installation and operation of the equipment are turned over to the operating department. In case a separate construction department is maintained, the installation should, of course, be under their supervision, but in accordance with method, information, and drawings supplied by the engineering department. The operating department would normally operate the equipment similarly to other equipment in a given area. In case special conditions are encountered a change in these general operating methods may be made. In this case the engineering department should check the operation to see that the equipment is operating so that damage to it will not result. When these conditions have been analyzed the operating department should be supplied information as to proper speed, length of stroke, pump, etc., that should be used or tried.

If equipment is selected to fit a particular well's requirements, it is necessary that this equipment be operated as anticipated; otherwise trouble may result. Counterbalancing is very important as by improper counterbalancing the stresses and loads in the transmission can be varied more, for example, than by a moderate increase in pump size. Insofar as operating practices influence the life or maintenance cost of equipment, the engineer should be free to check and study experimentally his problems. He should be able to have the operating department make any required changes that would result in improved operating conditions. The actual making of the changes and seeing that the spirit of the changes is carried out is an operating problem.

In making these studies it is frequently necessary to use all the special devices and techniques available. A well study is no longer complete unless it has dynamometer data and bottom-hole pressure or fluid-level data available. These are frequently routine tests. Although the collection of some of these data is routine, the analysis requires careful engineering study.

The analysis of bottom-hole samples is more in the nature of a special study. It ties-in with many other special problems such as reserves and particularly with some of the newer developments such as production from a single-phase reservoir. This work can be classed either under mechanical or chemical engineering work. It is in reality a specialized engineering problem in thermodynamics and as such would come under either field. New developments and practices will undoubtedly require the collection of more data and the devise and use of new and improved testing methods.

The above discussion has been along the lines of what the engineer should do. Here again a mention of what he should not do is probably in order. Once the equipment has been decided upon, he should have nothing further to do with it until it is put into operation, with the exception that he may wish to inspect it to see that it is installed according to standard practice and drawings. After the equipment is installed it may be necessary to check its operation if operating conditions appear to be much different than expected or if different than other equipment in the area. Also, if trouble develops the engineer should investigate to see what changes in operating conditions or design of the equipment might be effected to eliminate the trouble in the future.

Recent developments in new types of equipment and design of conventional equipment to a price requirement make it advisable to give the equipment problem careful engineering study. The rational selection of equipment on the basis of engineering principles together with applied repair cost information offers a very good opportunity to keep investment and maintenance costs at a minimum.

The problems of plant and system designs tie-in to some extent with equipment selection and application. Here again there is little question as to division of work as any type of plant design requires that certain functions be fulfilled in the most economical manner. Once design sketches have been made and equipment selections made, the problem is then one of layout in the drafting department, and one of construction by the operating department.

The problem of operation and production cost analysis is very important. With the industry operating on a very small profit margin every saving in operating or repair costs is very significant. In the case of operating expense such items as the labor requirements of various types of equipment may be significant. Here again is a place where the responsibility for such an analysis can be made the duty of the operating or engineering units. In any case close coöperation is necessary for realizing full benefits. In the solution of operating problems there are definite opportunities for the industrial engineer. The fact that production operations are spread over wide areas tends to make the handling of labor inefficient and difficult at best. There are possibilities for the application of control and routing methods that have been developed for other industries. These applications are not easy to introduce. They are mentioned here as a possible field for the mechanical engineer who has specialized along industrial lines. The analysis of production costs may also indicate where special handling methods, changes in power source, etc., may be employed to effect savings.

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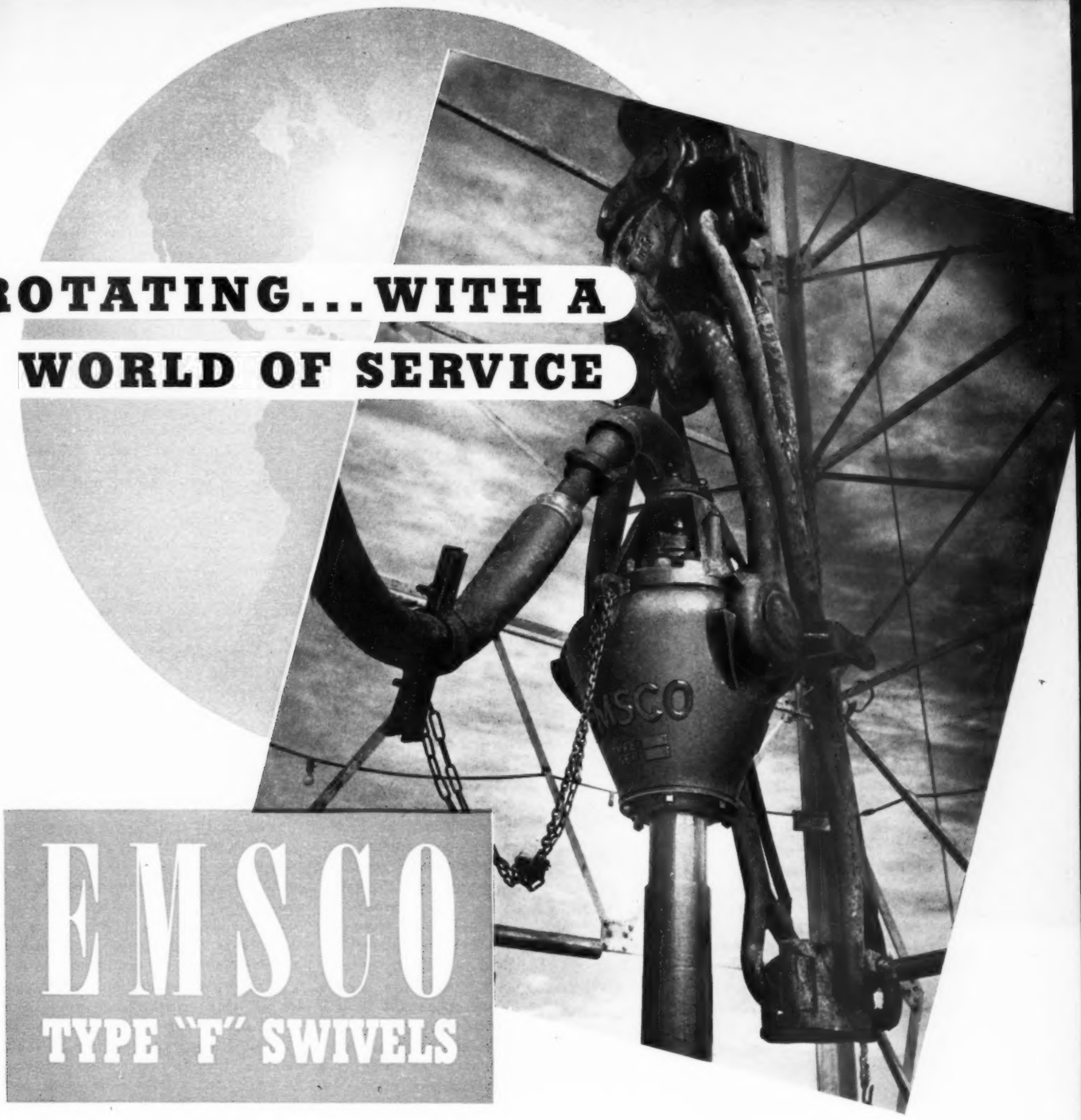

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must be carefully analyzed. They should have a very definite place in influencing equipment selection, writing of equipment and materials specifications, standardization, and in the design of equipment. When carried out in connection with a careful study of the physical failure of equipment, it should result in improvement in design of equipment or in repair methods or policy. The study of equipment failures and their attendant costs may make it possible to work out certain general policies or methods of replacement that would result in a general savings and in more important and satisfactory practices. An analysis can be applied to bring about elimination of the trouble and thus reduce operating cost. Inasmuch as many of these changes involving revision of design or changes in operating methods will be technical in nature the analysis of repair costs should, if properly made, yield the best results if done by a competent engineer. Much of the work of compiling the data from accounting department records will be clerical in nature and should be done by a clerk and not an engineer.

Operations

Generally speaking, operating problems whenever possible should be handled by the operating unit. As has been indicated above, once the engineering analysis and the final recommendation have been made, taking into account all phases of the problem including those that will arise in operations, the engineer should no longer be concerned with the work. The carrying out of the recommendations are properly the responsibility and duty of the operating unit. The engineer should follow the development or change in a general way, particularly in the case of something new, to be able to give help or suggestions should unforeseen difficulties develop, or changes appear advisable.

Frequently, there is a tendency to turn the writing of reports, collection of statistics, etc., over to the engineer because of his training along these lines. Care must be exercised to see that the engineers as such are not overburdened by such clerical work. It is generally much cheaper and more satisfactory in the long run to have clerical work done by clerks and to have operating reports written by the operating men.

The case of pumping wells has generally been covered in the previous discussions. For flowing wells certain experimental data are required in determining the best operating conditions. The collection and analysis of these data are primarily engineering phases of the problem. Whenever possible apprentice engineers or roustabouts should be used or assist in the routine work required for the collection of data. When the best operating condition is found, here again the problems of equipping the well and seeing that it is operated as specified belong to the operating unit.

In many operating problems engineering information is frequently required. Salt water disposal problems might fall in this class. Information on capacity of lines, size of pump required, possible disposal well capacity, etc., can be supplied by the engineers without their in any way becoming involved in the actual operation of the water disposal system. Although an engineer is usually capable of handling operating problems, such work is not strictly engineering. If he wishes to be an operator he should be so classified and should specialize in that work.

Petroleum Engineering

A. Drilling. The mechanical engineering phases of drilling as listed, primarily involved equipment or material problems. The petroleum problems as listed in Table 2 are principally those connected with getting a satisfactory completion of the well and the required information on formations drilled.

Although the chemist makes recommendations for certain special mud conditioning, the petroleum engineer should follow the mud conditioning in the field and see that it is doing what is required of it. The importance of proper mud conditioning even for routine drilling makes it necessary for the engineers to specify what constitutes proper mud conditioning and to set up control methods.

Core analysis, the correlating of drilling and geological information, and the analysis of electric logs are very important functions of the petroleum engineer. As the proper analysis of this information may mean the difference between a successful completion or a poor well, or in case of wildcat or semi-wildcat wells, may mean the location of or passing up of profitable production, it deserves the most intensive study. No small part of this study is that of reviewing new methods and studying possible improvement of existing methods. Because of the very involved nature of the problem and the fact that you "get only one look," this is a most critical part of drilling and must be given its proper study.

The petroleum engineer from his very careful analysis of the drilling, core, and electric log data, together with information on the actual performance of the well is qualified to determine the proper policy with regard to development of proved or semi-proved acreage. The geologist should be primarily concerned with the location of new pools or in supplying the unit data often required.

B. Production. The province of the petroleum engineer in production is primarily in connection with reservoir problems. The study of reservoir behavior really constitutes a special field in which principles of fluid mechanics and thermodynamics are applied. Because of its highly specialized nature it is frequently classed as one field of petroleum engineering. It could just as logically be classed as a field of fluid mechanics, which is a branch of either mechanical or chemical engineering. As mentioned before, this is a matter of nomenclature and not one of principle.

These problems of reservoir performance or control vary from completion methods of new wells to abandonment of old wells. In areas in which oil, water, and gas are present in different closely related horizons, the study of completion whereby control over these fluids may be established is a very important function. As the location of these horizons is one important phase of the problem, the petroleum engineer through his knowledge and information obtained in drilling is obviously in the best position to pass on these phases of production control.

The study of reservoir performance as a basis for imparting information on reservoirs, type of reservoir, best method of operating reservoir to obtain most economical recovery, and possible advantage of pressure maintenance is an important function of the petroleum engineer. He should have the responsibility and authority to pass on all these important engineering problems. As the best method may not always be applicable because of methods used by offset operators, or because of proration or other state regulations, his recommendations necessarily have to be passed on to see that they fit other requirements as well as company policy.

After the reservoir has been depleted to or near its economic limit by natural methods, or preferably early in the life of the field, consideration should be given to the effect of possible secondary recovery methods on oil recovery from the reservoir. Once the investment in drilling and equipment has been made, any increase in recovery above the cost to obtain that recovery represents a profit and if this profit can be obtained with a low investment thus reducing the economic hazard it may be a more desirable investment than in a new well. Although much work on secondary recovery has been done, the data available on its effects

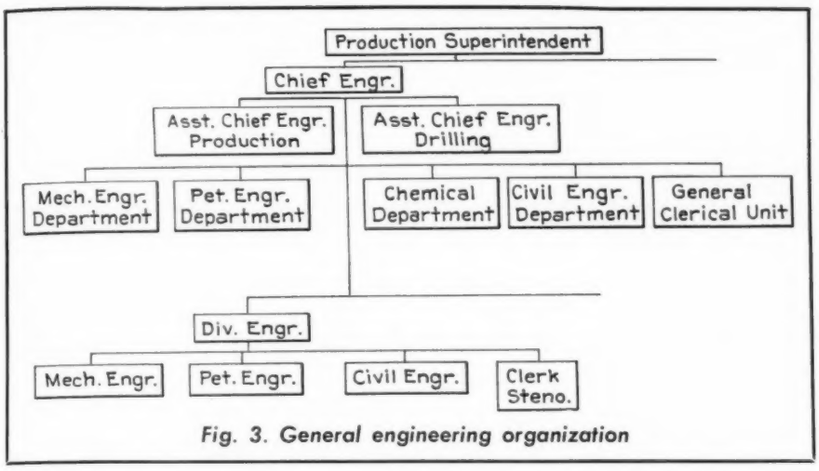


Fig. 3. General engineering organization

are not very extensive. The petroleum engineer can do much along the lines of secondary recovery, among which is the collection of data on actual pool performance under secondary recovery methods. This covers the study of repressuring, water-flooding, use of vacuum, and possible pressure maintenance.

In these subjects the engineer is responsible for such problems as determining proper volumes and pressures of injection gas in connection with repressuring work. The proper depths for locating packers to control the movement of gas is likewise an engineering problem. In connection with waterflooding the engineer is responsible for studying proper volumes, pressures, the injection rates, the proper producing methods, and the best way to operate the reservoir. The chemist should handle recommendations concerning treatment of the water.

The problems involved in increasing a well's capacity are connected very closely with reservoir performance and are also dependent on the application of drilling and other related data so that they should come under the supervision of the engineer. These problems may be listed generally as shooting, acidizing, squeeze cementing, chemical water shutoff, and well cleanout. These might be classified broadly as reconditioning jobs; plug-back to obtain other production may also be included in this class. In the case of shooting the engineer's duties would be to determine the amount, location of shot, and method of loading the hole. The actual running of the shot, and the cleanout following the shot are properly operating problems. In acidizing work it should be the engineer's responsibility to determine the amount of acid, the procedure for treatment, and method of following up the treatment that the acid specialists plan to employ. The actual ordering out of the acid truck, seeing that an adequate oil supply is available for chasing the acid, seeing that proper lines are available, and for making necessary preparations for swabbing, pulling or running rods, and the actual supervision of the work are operating problems that should be handled by the operating unit.

The investigation of wells prior to abandonment is frequently a very complicated procedure, particularly if possibilities of deeper or shallower production exist. If such an investigation involves a review of the operating expense and maintenance expense together with future estimates, the petroleum engineering division should act as the clearing house for such information.

The petroleum engineer is conversant with drilling and completion data, and from the study of reservoir data is best equipped to study and make estimates of reserves. This is a most important function, particularly if it can be tied into general reservoir studies. In addition to general information for accounting, tax and financial statements, reserve data have frequently a very important application to operating methods, equipment selection and similar problems. These applications will increase as the ability to evaluate reserves based on early reservoir data becomes better developed. This is a field that deserves careful study.

Chemical

The general chemical engineering functions are involved when problems arise or control is needed over matters involving chemical processes, treatments, or knowledge. The functions of this unit can, in most cases, be equally well handled by an experienced chemist or chemical engineer. The chemical engineer has a broad engineering training and for that reason can be used for other work if necessary. This would contribute to flexibility and in the case of the small organization, make possible the satisfactory handling of part time chemical work.

As is indicated in Table 3, the duties of the chemist or chemical engineer are largely those of specifying treatments and making chemical tests. In this general field, there is one type of testing that could be more widely applied. That is, the examination of materials being purchased to see that they meet specifications, are the best available for the price, or are what is needed for the particular application.

Among the services on which the chemical unit can give very useful advice is the treatment of cooling or camp water. In many cases uninformed persons purchase chemicals for treating water that either do no good or that cost several times the cost of commercial chemicals that would be adapted to the requirement. The same general observation applies to the purchase of such materials as paraffin solvents. In this case materials are often purchased that do no good or that are not as good as something else available. Field tests can be made on such chemicals, but such field tests are much more expensive than is ordinarily considered. A great deal of time is spent in making such tests, collecting field data, or employing additional well servicing to check up on the effect of the chemical. This work can become burdensome and is expensive. The major objection to such testing in general is the lack of control. Well conditions may change or test conditions can vary from one test to another, resulting in incorrect conclusions. The best method is to use inexpensive laboratory tests to eliminate all but one or two of the most promising chemicals on which field tests should then be made. Such a procedure will reduce the cost of making the tests and will result in a better product, perhaps at a lower cost.

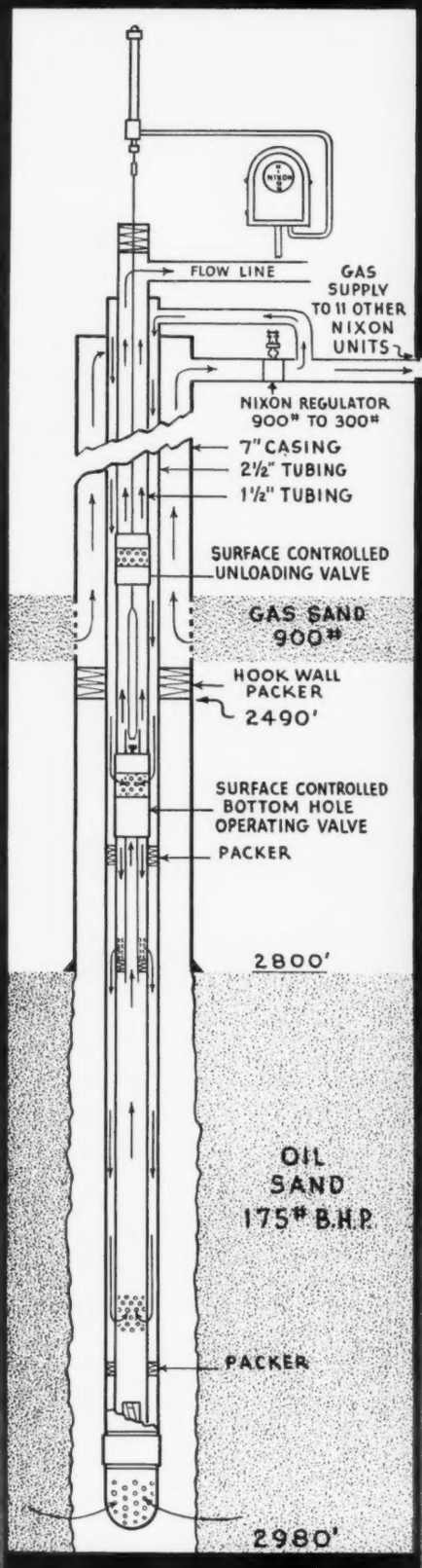
Control tests, particularly if chemicals are purchased in large quantities, are desirable if made with reasonable frequency. This practice gives the purchaser added assurance that he is receiving the product specified. This control will in the long run result in a better product because the vendor, knowing the check is being made, will take proper precautions to see that his product meets the specification.

Corrosion is a very broad subject and one on which the specialist is frequently baffled. It is a most important oilfield problem and should have more attention than it has received. The corrosion problem has been listed as a chemical function. It should really be a joint mechanical and chemical problem. The mechanical unit should report the corrosion problems to the chemical unit together with information as to what the problem is, the im-

(Continued on Page 66)

We used its o

to lift fluid in



NIXON DUAL ZONE INSTALLATION

However, overlying the entire area at approximately 2400 feet, is a high pressure gas sand. Our Nixon Gas-Lift engineers recommended utilizing the energy in the upper gas sand by a Dual Zone installation of Nixon Surface Control Gas-Lift System.

In one centrally located well, the 7" casing was perforated opposite the high pressure gas sand. A string of 2½" tubing was run to bottom and a hook wall packer set just below the high pressure sand.

Gas is brought to the surface through the annulus between the 2½" tubing and casing at 900 lbs., and reduced through a Nixon Selective Flow Differential Regulator to 300 lbs. This gas pressure is then used to lift the fluid from its own well and eleven others.

The 1½" tubing, inside the 2½" string, carries a regular Nixon Surface Control Gas-Lift installation with Bottom Hole operating valve. Operating gas pressure enters through the annulus between the two strings of tubing, intermitted through the operating valve, to lift

own "BOOTSTRAPS"

n 11 more wells!

fluid as it builds up in the inner tubing string. The [illegible] and none of the operating pressure reaches the producing sand. The other eleven wells have standard closed Nixon Surface Control Gas-Lift installations.

By making this installation, our engineers saved the operator the expense of drilling a gas supply well or the installation of a compressor station. They make it possible for the operator to take out all the oil each well is capable of producing without changing or adding to the gas-lift equipment, and without injuring bottom hole pressures.

Scores of fluid-lifting problems are being economized, modernized and simplified by Nixon Gas-Lift engineers. Tell them your problems. They have a Nixon Surface Control Gas-Lift installation that will save you money.

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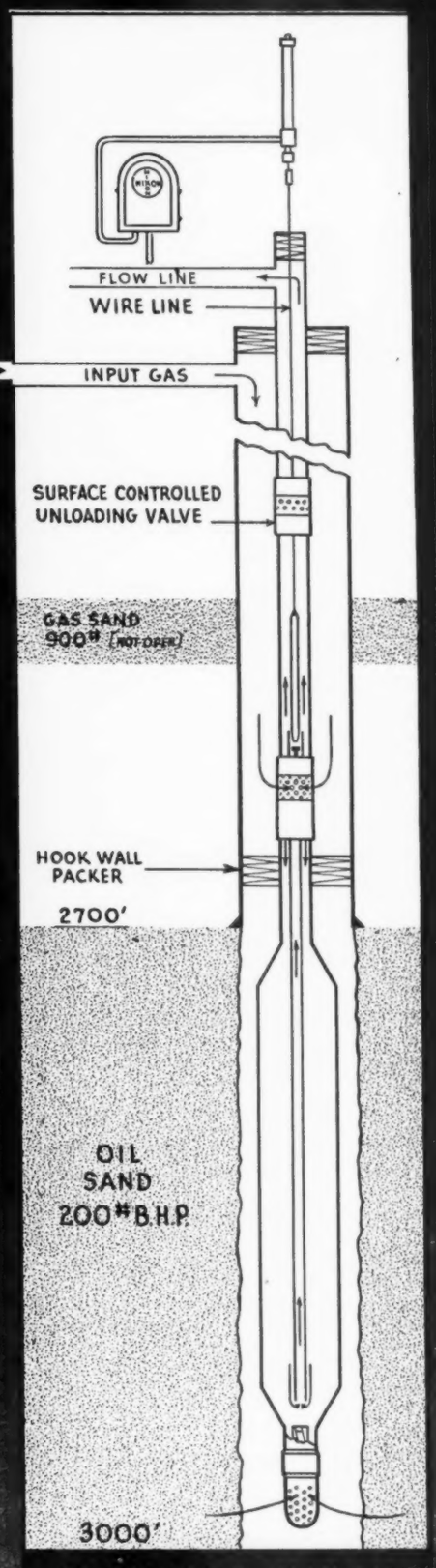

STANDARD NIXON SINGLE ZONE INSTALLATION

(Continued from Page 63)

portance of it, and any limitations that might influence remedial measures. The chemical unit should study the problem from a prevention or protection angle and then recommend possible prevention measures. The mechanical unit should then attempt to apply these measures to the design or operation of the equipment or material. In a small organization it may be best to have one man handle the entire problem.

The treating problems as listed are generally tied in with operations. In many cases they concern equipment and generally could best be handled by routing them via the mechanical unit for approval or handling. Here again care should be taken to outline what the unit should do as well as what it should not do. It is very easy to carry the problem one step further and get into the design or operation problem.

Civil Engineering

A large part of civil engineering work is concerned with the problems normally associated with that branch of engineering. The making of locations for wells, topographical surveys for special purposes such as drainage, location of lines and lease development are typical examples of civil engineering duties. In many cases the making of schematic maps of equipment locations on various properties can be made by the clerical unit, particularly if these maps are made for record or general information only.

The supervision of construction is normally a duty of this division. Here the duties should be limited to the installation of the equipment according to the drawings and specifications supplied. The inspection of contract work and the supervision of repair work are important functions. No matter how good the drawings may be or how simple the job, without inspection or supervision a poor job may be done that would result in trouble, costing many times more than the cost of proper supervision. The cost of doing the job right is little, if any, more than doing it well enough to get by and the value of a good job is much more than a poor one.

The supervision of drafting work, map making, keeping records of drawings and other associated work can best be handled by this unit.

Organization of Engineering Department

A review of the subjects listed under each of the engineering units shows that many of the items have to pass through several of the units to be most efficiently handled. To correlate the work of the units and to administer and assign the work is the duty of the chief engineer. He is most frequently placed in the production department and reports to the production superintendent as is shown in Fig. 2. If he were set up as are the other specialty groups such as geological, purchasing, etc., he would report to the executive department and would be on the level of the production superintendent. As a unit the engineers will generally number more than any of the other specialty groups and so far as numbers are concerned would be as deserving of being in a separate unit as any of the other units. Their functions are, however, very closely connected to the operating unit and as their real purpose is to handle technical problems and assignments in that department, functionally they belong in the production department. As mentioned before the important thing is the amount of authority and responsibility they have and not where they are in the organization structure.

The following discussion will be based on the assumption that the engineering work will be placed under the production superintendent as is shown in Fig. 2. As engineering is an important function the chief engineer should rank on an equal basis with the assistant superintendents. In the division, the division engineer should rank next to the division superintendent whether he is under him or set up in charge of engineering in a functional type organization.

To illustrate generally the form such an organization should have, Fig. 3 has been drawn. This chart would correspond to a large engineering unit. In the chart assistants to the chief engineer have been shown to assist in handling supervision of work normally considered as applying particularly to each of these branches of the work. The general office organization is shown with each of the four engineering units, i. e., mechanical, petroleum, chemical, and civil. In addition a general clerical or statistical unit is shown. Although these duties can be handled by engineers, as will be discussed later, this is neither advisable nor economical.

In the division organization the chemical unit is not shown. As a general rule the work of this unit can best be handled at a central laboratory. Also, if its results are passed through one of the other units who apply the results, a field organization is not required for the group. In a field organization the clerical-stenographic unit has also been shown. It is a most important unit in that it permits a smaller number of engineers to handle a given amount of work. Frequently, the addition of a clerk or stenographer to a unit will increase the output of the unit much more than the addition of one or more engineers. In both the field and central office departments no detail has been shown as the number and duties will depend on the size of the organization. In a small or relatively inactive division there may be only one engineer whereas in an active division there may be a number of engineers in each unit.

The future possibilities with regard to advancement in any organization will have an important effect on the development of the men and in holding good men. In a producing organization engineers may go into operating work or continue in engineering or technical work. In the operating unit they lose their engineering identity and are competing with men whose training often is of the practical type. Here their advancement depends on being able to handle men and equipment and on their experience. In engineering work as outlined in the above discussion the engineer progresses depending on his ability to apply technical knowledge to practical problems. The advancement of the man who goes into operations can be from roustabout, gang pusher, foreman, division superintendent, and to general superintendent. The engineer goes from apprentice engineer to engineer, division engineer, and chief engineer. If he is to progress further he must transfer to operation work and does not advance necessarily because of his engineering ability.

The general set-up of organizations is such that operating positions are the higher paid positions. In the oil-producing organizations the operating positions from division superintendent up are essentially executive positions. The requirements are a reasonable acquaintance with the business and a display of executive ability. The division superintendent's responsibility is the administration of the work being done in his district. The district engineer, if he has ability along this line, should be equally capable of handling a division position as is a foreman. If the division engineer's salary was equivalent to or better than a division superintendent's he would not be interested in the operating work. For this reason, it may be difficult to keep good engineers interested in engineering work. Only by elevating the salary level and by making an engineer's position and salary equivalent to corresponding operating positions can the good engineers be encouraged to stay in the engineering department.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer.*

4-Way Load Distribution

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"OILWELL'S" No. 300 Crown Block in service, viewed from the fourble board of a big Gulf Coast rig.

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Adequate Equipment Records As A Control in Pipe-Line Station Maintenance

PART 3 (Concluded)

by H. Lee Flood
Associate Editor

IT has been interesting to note the trend in the number of failures reported. It has been exceedingly gratifying to witness a decided decrease in the total number of failures per year from 266 during 1937 to 100 during 1940. At most stations, the decrease in the number of failures has been at a more or less steady rate. In a few instances, more failures were reported during 1938 than during 1937, which may have been due to a retarded understanding of the full scope of the failure report. In other words, many minor failures may have gone unreported during the first year.

Undoubtedly the most important result of the more intensive study given to maintenance of equipment has been the drastic reduction in the number of emergency shutdowns. As further evidence of the first class operating condition of the equipment during recent peak loads every pump and engine in the system has been in operation, thus bringing into service equipment formerly held religiously as standby for emergencies. In brief, this means that equipment maintained properly needs no standby provision. This may be quickly translated into savings of thousands of dollars in invested capital in pumping equipment.

Annual Overhaul

As a further step in completing the records of mechanical equipment, the form shown in Figs. 2a and 2b is filled out at the time of the annual overhaul of every pump and engine in the system. The form has been filled in, using hypothetical names and conditions in order to illustrate the type of information desired.

The advantages of such a form are being more generally recognized, inasmuch as several companies have devised similar sheets in recent years. Opinion seems divided on whether the greatest value in such a form is in its being a permanent progress report that may be studied and analyzed or whether it is more valuable as a check list to help prevent the repair crew inadvertently overlooking some phase of the work. Both points have equal merit and certainly a more orderly and systematic attitude prevails when such a form is in use.

It should be mentioned here that many of the suggestions for improved designs and practices come from the men at the stations. Certainly every effort is made to convey to them the feeling that their suggestions are welcomed, even expected. For example, in a letter written just following the completion of a general overhaul, it was said:

"The last annual overhaul of the machinery compared with the procedure used in previous years was thorough. The benefits will be fewer emergency shut downs, a lesser number of mechanical failures, more reliable operation and, consequently, lower operating costs. Your willing coöperation in carrying out this program is appreciated.

"Although less hard work will probably be required, the next overhaul will be even more thorough than the last one, because our efforts are being directed to a more intelligent understanding of the problems involved in the maintenance of the machinery. We are looking forward now to your assistance in developing procedures and methods that will mean a greater degree of perfection in the maintenance of the machinery—all of which leads to the point of this letter.

"During the period between the annual overhauls, valuable information pertaining to the maintenance of machinery comes to the attention of all of us. The observations and suggestions of employees, defective parts in machinery, mechanical failures, conclusions as to causes and remedies, better designs, new methods, better replacements and new developments constitute valuable information which should be studied and analyzed to see whether it could be used to good advantage in the maintenance of the machinery. Much of this information is put to no practical use and is lost, because in many cases the information can not be applied at the time it comes to our attention and without a systematic record, much of it is overlooked or forgotten when the annual overhaul is made.

"It is impossible for any person, or group of persons, in the organization to remember all the detailed instructions concerning replacements or work which should be done on different units throughout the system on the next annual overhaul. Likewise, other valuable information gained in the period between the annual overhauls, either from our own experience or from sources outside the company, can not be remembered so that it can be applied at the next overhaul of the machinery. We have concluded, therefore, that such information should be catalogued in a systematic manner, so that each person concerned will have it available for his guidance before the program of the overhaul of the machinery is started. It is proposed, therefore, that a record of such information be kept by the Chief Station Engineer, the Division Machinist, the Division Superintendents, the Master Mechanic and the General Superintendent."

In connection with the above endeavor to consolidate the information needed during the annual overhaul, the following letter lists the Operating Practices (OPs) recommended as necessary:

To All Superintendents,
District Foremen,
Division Machinists,
Chief Station Engineers.

Subject: Summary of OP Instructions for Annual Overhaul File.

Gentlemen:

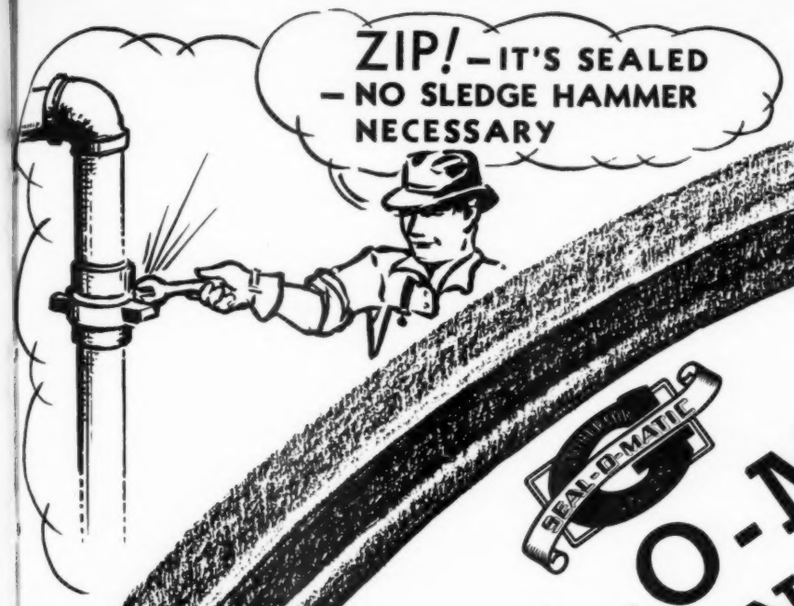
Various OP instructions have been issued covering replacement of certain machinery parts during annual overhaul. We find that these instructions are frequently filed away when received and when the annual overhaul is made the instructions are forgotten. To make such instructions available at the time of annual overhaul, they are summarized below.

OP#161: Changing of Engine Crankbolts every Four Years Running Time.

OP#168: Replace All Rubber Seal Rings on Crank End of Cylinder Liner Skirts Annually.

OP#210: Inspect Air Tank Heads, Valves, Sleeves, etc., every Six Months.

OP#215: Replacement Schedule for Cooling Coils in Air Compressors every Two to Five Years. Supplementing this



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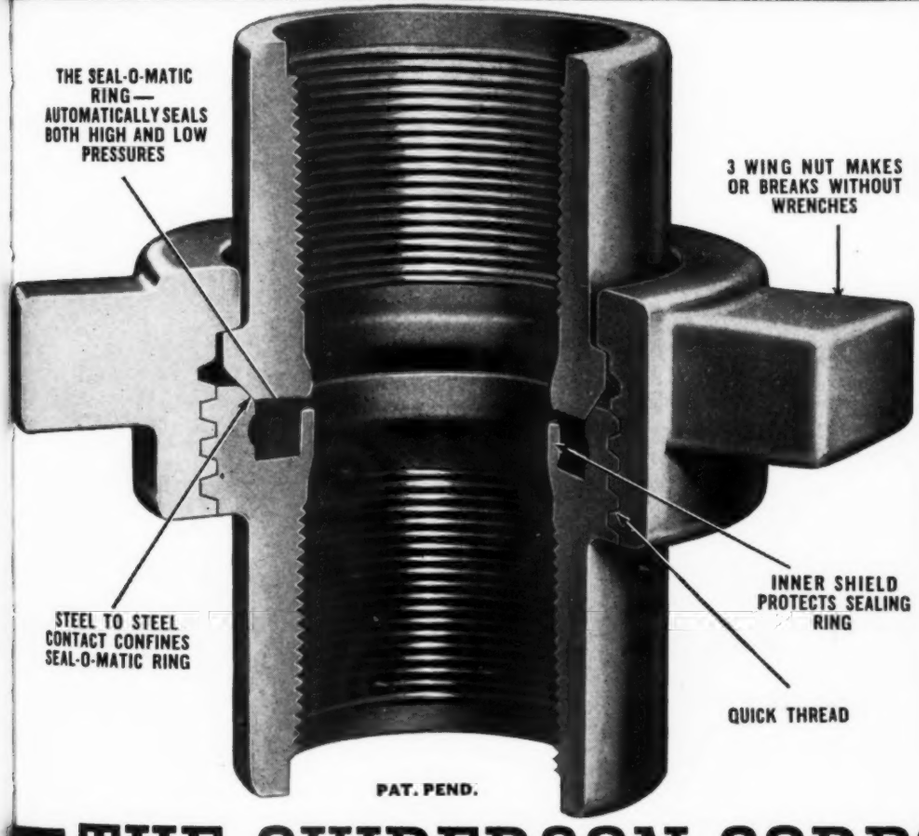
*per square inch.

Detailed information available at your Supply Store, or consult your 1941 Composite Catalog.


THE SEAL-O-MATIC RING— AUTOMATICALLY SEALS BOTH HIGH AND LOW PRESSURES
3 WING NUT MAKES OR BREAKS WITHOUT WRENCHES
INNER SHIELD PROTECTS SEALING RING
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QUICK THREAD
PAT. PEND.

This deliberately mutilated union did not leak at 12,000 lbs. per sq. in. test; demonstrating the astounding sealing qualities of the SEAL-O-MATIC Ring.

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DATE January 12, 1941 RECORD OF INSPECTIONS DURING ANNUAL OVERHAUL-ENGINE Form 188 PL

STATION Anymain UNIT NO. 4 ENGINE Morse Engine Co. S# 48-986 MFG# 68951 R.P.M. 200 H.P. 400

Cylinder No. (Divide Space Above Heavy Line For No. Of Cylinders. Leave Space For Scavenging Cyl. In 1 Cycle Engine)		No. 1 cyl.	No. 2 cyl.	No. 3 cyl.	No. 4 cyl.
Cylinder Head	New Or Reground - Date Installed	new 3-15-36	new 6-9-32	repaired 1-2-38	original
	Head Clearance After Overhaul	0.370"	0.375"	0.380"	0.373"
	Compression Press Before & After Overhaul	465B — 480A	460B — 475A	455B — 475A	460B — 475A
	Firing Press. Before & After Overhaul	530B — 520A	565B — 520A	595B — 530A	570B — 535A
	Total Thickness Of Compression Rings Of #302-D	1/4"	5/16"	3/8"	1/4"
	Cond Of Water Jacket - State If Cleaned	no scale	very little mud, all cleaned	jackets cleaned	
Exhaust Valve & Cage	Cond. Of Valve - Ground Or Replaced	good, ground	worn, replaced	good, ground	burned, replaced
	Cond Of Seat - " - "	✓ ✓	good, ground	✓ ✓	✓ ✓
Inlet Valve & Cage	Cond. Of Valve - Ground Or Replaced	✓ ✓	✓ ✓	✓ ✓	good, ground
	Cond Of Seat - " - "	✓ ✓	✓ ✓	✓ ✓	✓ ✓
Liner	Date Installed	Nov., 1935	Nov., 1935	Nov., 1935	Nov., 1935
	Hours Eng. Had Run At Above Date	75,783	75,783	75,783	75,783
	Total Hours Run On Present Liners	27,303	27,303	27,303	27,303
	Wear At Top Of Ring Travel — With Pin	0.098"	0.097"	0.095"	0.035"
	Wear At Top Of Ring Travel — Crosswise Of Pin	0.055"	0.052"	0.052"	0.090"
	Wear 3 Down From Top Of Ring Travel — With Pin	0.027"	0.031"	0.028"	0.023"
	Wear 3 Down From Top Of Ring Travel — Crosswise Of Pin	0.035"	0.026"	0.030"	0.025"
	Wear At Ports (2 Cycle Engines) — With Pin	4-cycle	4-cycle	4-cycle	4-cycle
	Wear At Ports (2 Cycle Engines) — Crosswise Of Pin				
	Measurement At Bottom Of Liner — With Pin	0.006"	0.002"	0.009"	0.004"
	Measurement At Bottom Of Liner — Crosswise Of Pin	0.008"	0.009"	0.007"	0.002"
	Greatest Wear Is Of Other Than Above	(288 "top") changed	(288 "top") changed	(288 "top") changed	(288 "top") changed
	Change Rubber Seal 2 Nos Per O.D. 168	10/30/34	10/30/31	10/30/31	10/30/31
Piston	Date Installed	50,790	50,790	50,790	50,790
	Hours Eng. Had Run At Above Date				
	Condition	T.R. grooves worn	T.R. grooves worn	T.R. grooves worn	T.R. grooves worn
	No Of Rings Found Stuck	3 new standard	2 new standard	all new standard	4 new standard
	No & Size Of New Rings	good	good	good	good
	Condition Of Piston Pin Fit & Locking Device	0.006"	0.007"	0.005"	0.005"
Crosshead Pin Or Piston Pin And Bearing	Pin Wear (Out Of Round)	5.999"	5.995"	5.996"	5.996"
	Repaired Or Replaced, Olive Pin Dia.	good	good	good	good
	Condition Of Bearing	0.004"	0.005"	new bkngsal 0.003"	0.004"
	Repaired, Replaced, Clearance	1-12-39	1-12-39	1-12-39	1-12-39
Piston Pin Bolts	Date Installed	92,744	92,744	92,744	92,744
	Hours Eng Had Run On Above Date				
	Remove Bolts From End. Check For Cracks, Stretch & Twist - State Condition	Good	Good	Good	Good
Crank Pin Bolts	Date Installed	1-12-39	1-12-39	1-12-39	1-12-39
	Hours Eng Had Run On Above Date	92,744	92,744	92,744	92,744
	Remove Bolts From End Check For Cracks Twist And Stretch. State Condition. Spot Heads And Nuts For Squats O.D.# 302-D	Good	Good	Backs stretched 0.030" New bolts installed	Good
Spray Valve	Condition Of Valve & Seat	Seat worn	✓	Good	Needle worn
	Timing Found - Degrees Open & Close	5½° — 33°	6° — 32°	5° — 35°	6° — 39°
	Timing Set - Degrees Open & Close	6° — 35°	6° — 35°	6° — 35°	6° — 35°
	Valve Lift Before & After Adjustment	0.121" — 0.125"	0.125" — 0.129"	0.120" — 0.125"	0.125" — 0.125"
	Repaired, Reground Or Renewed - Date	new seat 1-12-41	new seat 10-2-40	reground	new needle 1-12-41
Starting Valve	Condition When Inspected	Good	Good	Good	Good
	Cleaned Ground Or Renewed	Ground	Ground	Ground	Ground
	Condition Of Pump Valve Body	Good	Good	Good	Good
Fuel Pump & Fuel Pump Valves	Clearances State Lift For Ground Or Renewed	0.025" — Ground	0.026" — Ground	0.021" — Ground	0.023" — Ground
	Cylinder - Replaced Or Renewed	repacked	repacked	repacked	repacked
	Discharge Valves - Ground Or Renewed	Ground	Ground	Ground	Ground
	Show Discharge Valve Lift	0.024"	0.025"	0.027"	0.030"
	Suction Valves - Ground Or Renewed	Ground	Ground	Ground	Ground
	Show Suction Valve Lift	0.128"	0.130"	0.125"	0.132"
Main Bearings	Condition When Removed From Engine	all main bearings removed and repaired		found in good condition	
	State If Scraped Or Renewed	no scraping required on crankpins			
	Bearing Cap Clearance	#1 — 0.004" #2 — 0.007"	#3 — 0.007"	#4 — 0.008"	#5 — 0.006"
	Clean Crankshaft Oil Passages - State Work Done	all oil passages in crankshaft cleaned, and shaft inspected for cracks			
Crankshaft Thrust Bearings	Condition Of Bearings	Good			
	Amount Of End Thrust After Adjustment	not recorded (0.008")			
Crank Bearings	Condition When Removed From End	babbitt cracked	good	good	babbitt cracked
	State If Scraped Or Renewed	renewed			renewed
	Crank Pin Condition	Good	Good	Good	Good
	Crank Bearing Clearance	0.008"	0.007"	0.006"	0.007"
Compressor	Valves - Remove, Clean & Grind All Comp Valves - State Lift & Work Done	Low Suction 0.095" Ground; Intermediate Suc. 0.090" ✓; High Suc. 0.092" ✓		Low Disch. 0.075" Ground; Inter Disch. 0.080" ✓; High Disch. 0.087" ✓	
	Comp Cyl - Show Greatest Wear	Low 0.006" Inter. 0.012" High 0.017"	Show Clearance Between Piston & Head	Low 0.076" Inter. 0.065" High 0.090"	
	Cooling Coils - Show How Cleaned State Condition	Low coils in good condition — cleaned with chemical; Inter. ✓ ✓ ✓; High ✓ ✓ ✓			
	Inspect Clean & Test Safety Valves Of #175	all safety valves were inspected, tested and readjusted			
	Clean Air Intake & Intake Valve - Show Work Done	intake bell was blown out with air and throttle valve cleaned			
	Clean Injection Pump - Show Work Done	washed with hye water			
	Cond Of Cylinder & Piston - State Replacements	installed new high stage rings — other rings and piston in good condition			
	Clean & Inspect Air Strainer Panel State Work Done	inspected Gyro			
	Clean & Inspect Air Inlet Valves - State Work Done - O.P. 110	cleaned and ground valves			
	Cond Of Comp Cyl. & Cooler Jackets - State If Cleaned	washed jackets			
Lube Oil Pump Gears & Drive	Condition Of Gears - State Clearance	Good — 0.007" clearance			
	Check Drive - State Condition	✓			
Lubricator	Clean & Repair Lubricator - State Work Done	cleaned and inspected			
Fuel Pump Drive	Condition Of Drive - State Replacements	installed new drive pins			
Outboard Bearing	Inspect And State Clearance Given	inspected Clearance — 0.008"			
Cleaning	Clean & Inspect All Lube Piping - Show Work Done	removed and cleaned all lub. oil piping			
	Clean Engine Crankcase - Show Work Done	cleaned crankcase			
	Clean Lube Oil Supply Tank & Cooler - State Work Done	sump tank			
Governor	Condition Of Rods - Pins & Bearings	Good			
	Note Adjustments Or Replacements	none			
Timing Gears Or Chains	Condition Of Gear - State Clearance	Good — 0.002" upper 0.004" lower			
	Condition Of Gears - State Clearance	✓ ✓ ✓ ✓			
Camshaft	State Replacements - If Any	none			
	Condition Of Bearings & Gear	Good			
Vertical Or Lay Shaft	Condition - Reset Or Renewed	✓			
Air Intake Piping	Bearings - State If Scraped Or Renewed	none			
	Clean Air Intake Piping - State Work Done	intake blown out with air			
Exhaust Piping	State Condition Of Piping	Good			
	Condition Of Expansion Joints - State Work Done	repacked expansion joint			
	Condition Of Water Jacket - Show Work Done	washed out			

Total Hours Engine Has Run	At Date Last Overhaul	67,345
	Since Last Overhaul	8,438
	To This Date	75,783

THE WORK OUTLINED ABOVE HAS BEEN COMPLETED ON THIS UNIT AND THIS RECORD IS TRUE & CORRECT--- SIGNED

MACHINIST John Doe

CHIEF STA. ENGR. Bill Roe

DIVISION SUPT. M.B. Brown

Fig. 2a. Front side of 17-in. by 11-in. overhaul sheet

DATE January 16, 1941 RECORD OF INSPECTIONS DURING ANNUAL OVERHAUL OF PUMP Form 188 PL

STATION Anymain UNIT NO. 4 MAKE Morse Pump Co. S# X-4-9 MFG# 986 SIZE 6¼" x 18" Trip.

Pump Part	Work Outline	Divide Space Above Heavy Line As To No Of Sections Of Particular Pump. Pump Section Number: no. 1 section	no. 2 section	no. 3 section
Main Bearings	State Levels & Condition Of Bearings When Removed	shaft checks level and all bearings are in good condition		
	State If Renewed, Repaired Or Adjusted	all bearings adjusted		
	State Shims Added Or Removed To Align Shaft	no shims added or removed		
	State Bearing Cap Clearances			
Crank Pin Bearings	Condition Of Crank - Pins	babbitt cracked	Good	Good
	Condition Of Bearings - Scraped Or Renewed	removed		
	Bolts - State Condition & Date Installed	Good - installed 1-15-39	Good - installed 1-15-39	Good - installed 1-15-39
Crosshead Pins & Bearings	Condition Of Crosshead Bearings State Replacements	Good - readjusted	Good - readjusted	Good - readjusted
	Condition Of Pin - State Amount Out Of Round	Good - 0.002"	Good - 0.005"	Good - 0.005"
Crosshead Shoes	Condition - State Clearance Given	✓ - 0.010"	Good - 0.009"	Good - 0.009"
	Studs - State Condition & Date Installed	✓ - original	✓ - original	✓ - original
Packing	Kind Of Packing & Date Installed	Flat - 10/12/40 hand - repacked	Flat 10/12/40 hand - repacked	Flat 10/12/40 hand - repacked
	Condition Of Packing			
Packing Glands & Gland Studs	State Clearance Between Plunger & Gland	all glands have ½" clearance		
	State Condition & Date Installed	all studs in good condition - original studs		
Plungers	State Total Wear On Plungers	all plungers have about 3/32" wear		
	State Condition - Scored Or Smooth	✓ - ✓ in good condition		
	Check For Level With Crosshead; State Adjustments Made	no adjustment, all plungers level with crossheads		
Pump Valves	State No Of Leaky Valves Found Before Shutdown	3 leaking	3 leaking	1 leaking
	State Replacements Or Repairs	all valves ground	all valves ground	all valves ground
	Design Of Valves - Wing Or Ball	wing	wing	wing
	Material In Seats & Valves	steel	steel	steel
Pinion Shaft Bearings	Condition Of Bearings - State Replacements	all bearings in good condition		
	State Work Done To Level Pinion Shaft	shaft level		
Gears	Condition Of Oil Rings Or Chains	oil rings in good condition		
	Condition Of Master Gear	Good		
	Condition Of Pinion Gear	✓		
Crank Shaft	Center To Center Mmt. Before & After Adjustments	50.087" before & after		
	Check Fit Of Master Gear On Shaft	Tight		
	Check Fit Of Pinion Gear On Shaft	✓		
	Check Fit Of Cranks On Crankshaft	✓		
	Check Fit Of Crank Pins In Cranks	✓		
	Check Tightness Of Oil Throwers Rings	✓		
Gear Guard By Pass Valve	Check Guard For Tightness - State Condition	Good condition		
	Check By Pass & State Parts Replaced	✓		
	Mfgrs. Name, Type & Size	Plug type 4"		
Coupling - State Make	Check For Alignment - State Condition Found	alignment OK		
	State Spacing Coupling Set To	½"		
	State Replacements	none		
	Check Coupling Bolts For Tightness	Tight		
Belt Pulley	Check Tightness On Coupling - State Condition	✓		
Lube Oil System	Clean Lube Oil Piping - State Work Done	removed and cleaned all piping		
	Clean Lube Oil Filter - State Work Done	✓ ✓ ✓ ✓ ✓		
	Clean Oil Well's In Ring Oiled Bearings	cleaned		
	Clean Crankcase & Sump - State Work Done	✓		
	Check Lube Oil Pump & Drive - State Work Done	✓ - drive OK		
Conduit Drains	Clean Conduit Drains - State Work Done	✓		
Suction Header & Chambers	Clean Suction Header - State Work Done	✓		
	Clean Suction Chambers - State Work Done	✓		
Foundation Bolts	Check For Tightness - State Work Done	checked - all tight		

REMARKS:— ANY INFORMATION ON ENG. OR PUMP NOT INCLUDED IN WORK OUTLINE TO BE ADDED BELOW

Checked all connections between governor and fuel pumps and readjusted to original dimensions.

NOTE - AFTER THE ANNUAL OVERHAUL IS COMPLETED, THE ORIGINAL AND ONE COPY OF THIS RECORD WILL BE MAILED TO THE DIVISION SUPT. WHO WILL APPROVE AND SEND THE ORIGINAL TO THE MASTER MECHANIC.

Fig. 2b. Back side of 17-in. by 11-in. overhaul sheet

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DO YOU KNOW WHY THIS IS TODAY'S *outstanding* PUMP VALUE?

"Volume Producer." Quick installation, simple design and maximum cross-sectional displacement are the outstanding features of this pump. A precision pump for use in large volume wells, it is long-wearing, easily serviced.

"Petrol A." A low priced precision built pump for use in stripper wells, designed to reduce pumping costs to the core. Like all other FLUPACO Groove Seal Pumps, it conforms to A. P. I. specifications.

"Producer." An insert pump for wells of medium volume and depth. Has plungers of "Service" or "Supreme" alloys—wear-resistant and durable. Also has largest cross-sectional area available in insert construction.

WHY are more and more operators installing Flupaco "Groove Seals" as the efficient solution to their production problems?

Why are "Groove Seals" known to be far and away today's outstanding pump value?

There are many important reasons—but chief among them is this: *They're not only reasonably priced pumps to buy... but they also have the quality features which make them economical to use!*

Groove Seals construction gives you smoothness under all operating conditions. That's important in reducing equipment wear, preventing breakage, keeping pumping costs down.

Groove Seals are completely modern pumps. Every part in every pump is the product of the latest methods... latest developments... in Flupaco's advanced manufacturing methods.

Groove Seals meet the production requirements of any well capable of using insert (rod) type pumps. Big or small volumes... light or heavy crudes... deep or shallow pumping—there's a "Groove Seal" ready to handle the job.

Groove Seals are made—and stocked—in sizes, types and metals to provide you with exactly the pump to efficiently meet your special well conditions.

With Fluid Packed Pump's constant improvement of methods and workmanship back of these pumps, your dollar actually buys *more* today when you order "Groove Seals." So before you buy *any* pump, ask the Fluid Packed representative nearest you for the full story on the Flupaco "Groove Seal" line—or write direct.

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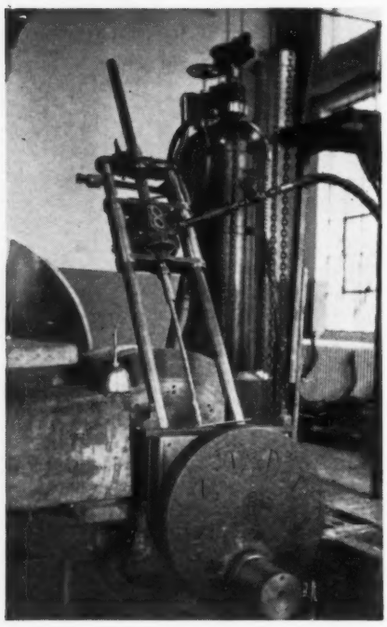


Fig. 3. Close-up view of pneumatic drill and jig used to drill crankshafts for pressure oiling

instruction. In the future these coils will be inspected annually and replaced only when necessary, due to corrosion or erosion.

OP#264: Replace Ball Bearings in Vertical Shafts of Engines Annually.

OP#275: Test all High, Intermediate and Low Pressure Air Compressor Relief Valves Annually.

OP#286: Replace All Rubber Seal Rings Annually on Cylinders, Cylinder Heads, Piston Heads, Air Compressors, etc.

OP#289: Replace Ball Bearings Annually in High Speed Equipment such as Electric Motors, Centrifugal Pumps, etc.

OP#291: Stencil Dates on All Machinery Replacement Parts When Installed.

OP#302-B: Tightening Engine Crank Bolts.

OP#319: Replace Gauge Glasses in Surge Chambers Every Three Years.

OP#326: Clean Crankcases and Lube Oil Piping 750-hp. Engines every Six Months.

Suggested reference reading before starting annual overhaul:

OP#54-A: Combustion and Mechanical Knocks in Diesel Engines.

OP#167 & OP#167-A: Procedure and Tolerance in the Alignment of Engine Crank Shafts.

OP#292: Fitting Piston Assembly.

OP#302: Tighten Crank Bolts.

The extra copy of these instructions will be filed in the Annual Overhaul File, where they will be referred to each year before overhaul of machinery is started.

Yours very truly,
Signed by
Master Mechanic.

Fig. 4. Operating drill shown in Fig. 3

Mechanical Improvements

It has been mentioned that the tabulated data in the Mechanical Failure Records have stimulated various studies and investigations of problems previously not considered serious. Of the many different types of studies made, some of the more interesting have been in connection with adapting bearing metals for various types of service, methods of repairing large machine parts by welding, and redesign of spray (injector) nozzles on Diesel engines.

One of the more extensive modernizing programs undertaken in recent years that was suggested more or less directly by the increased attention given equipment maintenance was the conversion to pressure oiling of all the older equipment purchased when splash oiling was the only method available. All crankshafts were drilled using the pneumatic drill and jig shown in Fig. 3. Fig. 4 shows the drill being operated.

Another study now in progress involves a determination of the proper amount of torque that should be applied in tightening a stud bolt. Engine men have known for years that bolts can, and often do, exceed their elastic limits. Investigation found that little dependable information on permissible torques is available so these data are now being obtained. To complete the study properly even required the design of a torque-indicating wrench of sufficient capacity to accommodate the large bolts involved.

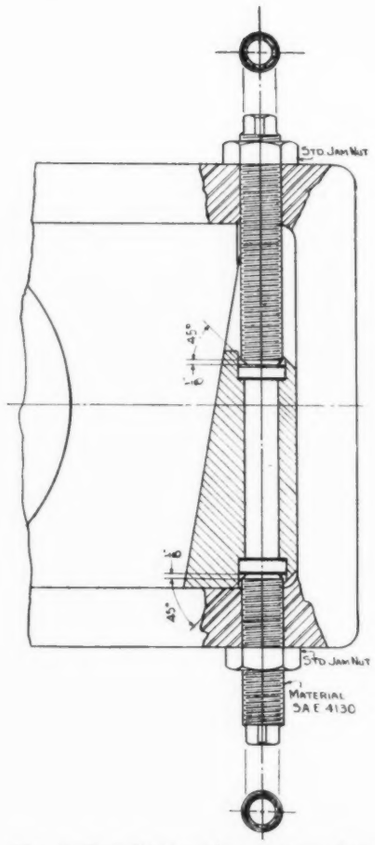


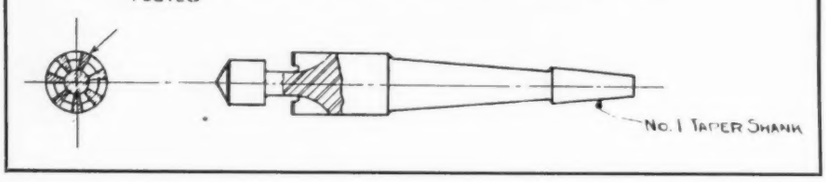
Fig. 5. Detail of wedge designed to place bolts in compression

Before many mechanical failure reports had been received, attention became centered on the abnormally high number of failures in the bolts used to tighten bearing wedge blocks. The bolt engaged a threaded hole in the wedge and as the bolt was turned the wedge would force the bearing against the journal. The design was such, however, that the bolt was always in tension and it was the excessive tensile stress that was causing failure.

Fig. 5 shows the method of redesigning the wedges and bolts so that the adjusting bolts are now in compression instead of tension. The work required was: (1) milling seats for the hardened steel disks against which the set screws act and (2) tapping the connecting rods to receive the threads of the set screws.

To mill the disk seats within the body of the wedge, a special end mill

Fig. 6. Special drill used in revamping bearing wedges



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Ready to take those fast, *extra* round-trips when you're drilling in, thus J&L Permaset gives added dependability and security at that critical time when a wire rope failure would mean serious loss and delay in your operations.

The superior quality built into J&L Permaset comes from the unique J&L combination of men, materials and machines; men with an average of more than ten years rope-making experience; wire drawn from J&L Controlled Quality Steel; and machines of the most advanced design, *pre*form and weave wires and strands into stress-relieved lines having uniform close tolerance.

For speedy, safe, economical drilling, the next time you string your rig use J&L Permaset Preformed Wire Lines. J&L distributors near your wells are ready to give you fast, efficient service.

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had to be designed, shown in Fig. 6.

To adjust a bearing with the new-designed wedge, the bottom set screw is used to raise the wedge until the desired position is obtained. The top set screw is then tightened against the top of the wedge so that the wedge is held firmly in place and both bolts are, of course, in compression.

Following the above change, there has been an almost complete lack of trouble from this source. The number of potential points for trouble is evident when it is recognized that every crosshead and many of the crank ends of every pump in the system involves wedges of this type.

Summary

It has been possible to do little more than sketch briefly only a few of the elements that enter into an adequate maintenance program.

Reviewed briefly, the establishment of a routine for reporting mechanical failures and particularly points where failures are imminent has aided materially in analyzing the experience of the company as a whole and has resulted in worthwhile improvements.

Greater attention to detail and authorization of complete checkups in annual overhaul work has definitely reduced the number of emergency shutdowns and has had the intangible effect of creating greater pride of workmanship and of lessening the mental tension that was ever present formerly when an emergency shutdown was always imminent.

Summarizing the benefits derived from these practices, some of the more tangible are:

1. Use of standby equipment to increase capacity whenever necessary.
2. Reduction in number of emergency shutdowns.
3. Reduction in number of mechanical failures.
4. Smaller parts inventories at stations.
5. Smaller full-time repair crews.
6. Increased attention given to mechanical problems.

P 069.

Chart for Determining Acreage in Rectangular Plot of Ground

by

W. F. Schaphorst

HERE is a chart that many oil men will find handy for quickly determining acreage of any rectangular plot of ground, regardless of how long or wide.

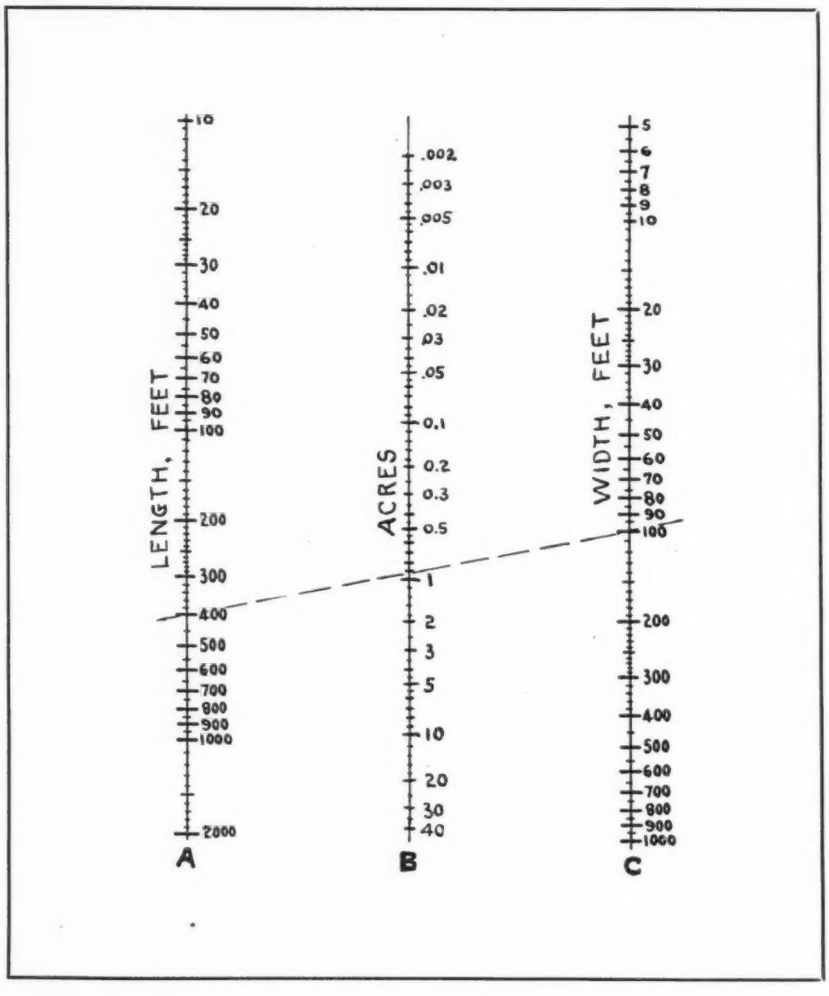
For example, the dotted line drawn across the chart shows that if a plot of ground is 400 ft. long (column A) by 100 ft. wide, (column C), the acreage is slightly more than 0.9. Estimating with the eye you can see that 0.92 acres is about right.

The same dotted line would also show that if an oil lease is 4000 ft. long by 100 ft. wide, it would amount to about 9.2 acres.

If the lease is 40,000 ft. long by 100 ft. wide, the area is 92 acres.

In other words, add as many ciphers to the answer in column B as the sum of ciphers or digits added in columns A and C.

Experiment with the chart a bit and you will appreciate how convenient and valuable it is.



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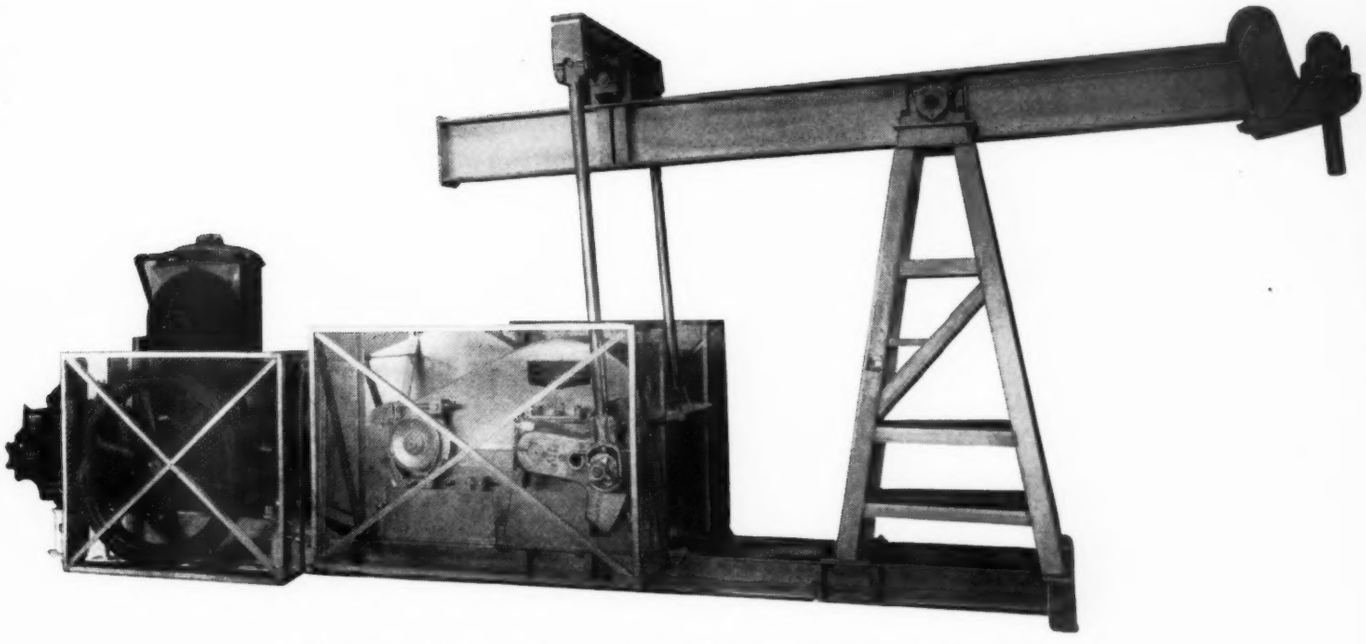
Any Type; Any Size: 7 to 135 H. P.

Meet Any Condition on Any Well in Any Field



OCS Pumpers Can Be Furnished with Crank and Engine Flywheel Guards Which Meet the Most Rigid Safety Requirements

OCS Pumping Units are more than "just so much equipment." They are "tailor made" to meet the most exacting requirements of your individual well and the conditions of your particular lease. Available in any size or type; Single or Double Reduction; from 7 HP to 135 HP, OCS Pumpers are the result of many years of actual field experience and engineering knowledge coupled with skilled workmanship and modern manufacturing facilities.

The place which OCS has occupied as a pioneer in the advancement of pumping equipment design and efficiency has become one of leadership in today's construction and field performance.

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—THE OIL COUNTRY SPECIALTIES MFG. CO.

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Sales and Service Branches in All Active Fields

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New Metropolitan Pipe Line Equalizes Distribution Pressure

Exclusive

☆ Installation of 30,000 ft. of 12-in. and 16-in. pipe line provides Houston, Texas, with better pressure control on city system

by Robert M. Hutchison

Chief Engineer, Houston Natural Gas Company

FIFTEEN years ago, the Houston Natural Gas Corporation brought natural gas to Houston and began the construction of a gas distribution system designed to serve a rapidly growing community, a growth contributed to by a ship channel, 17 railroads, vast agricultural expansion, an abundance of oil and gas, and an influx of industries.

The first natural gas was transported by pipe line a distance of 450 miles. During the last 15 years, however, Texas has become a drillers' paradise and Houston, fortunately situated with respect to the important fields of the Gulf Coast, has attained a metropolitan population of half a million persons. Year after year, the Houston Natural Gas Corporation has extended its distribution facilities to keep step with the expansion. In 1940 it was found necessary to increase the capacity of its city loop line in order to supply adequately the expanded demand of its distribution system.

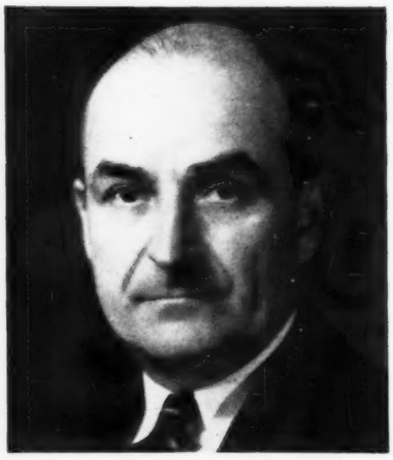
Accordingly, plans were made for the installation of an additional feeder main to begin at the city limits and join the city loop at its center. In this way, the pressure in the city loop that encircles the city and is fed from both ends, could be equalized throughout and the maximum requirements satisfied without need of appreciable variation of inlet pressures at any of the three points at which gas enters the system.

The route finally selected required the installation of 11,000 ft. of 16-in. O.D. and 19,000 ft. of 12¾-in. O.D. pipe laid partly through undeveloped territory and partly on city streets.

The pipe used is A.P.I., grade B, seamless tubing of 40-ft. random lengths. Each joint end was beveled for welding and was shipped from the mill free of paint, lacquer, or other protective coating. The pipe was cleaned, primed, coated, and wrapped at a local pipe-wrapping plant, the protective coating consisting of approximately 3/32-in. of low-boiling-point coal-tar enamel, applied hot; a 15-lb. asbestos felt wrapper, and a kraft paper. Both the wachine-wrapped sections and the field-coated joints were tested for holidays with a detector before being placed in the ditch. The line was electrically welded throughout except that a long sleeve coupling was installed at intervals of approximately 1000 ft. Three beads were used on all welds in the straight sections; four beads were applied at angles and turns. Welded fittings of the proper curvature were used at all changes in direction.

Each welder was required to submit a sample of his work to a testing laboratory to be X-rayed and contorted. In addition, several welds were cut from the line and tested during construction. These precautions were amply justified when the pressure test disclosed a tight line after the work was completed.

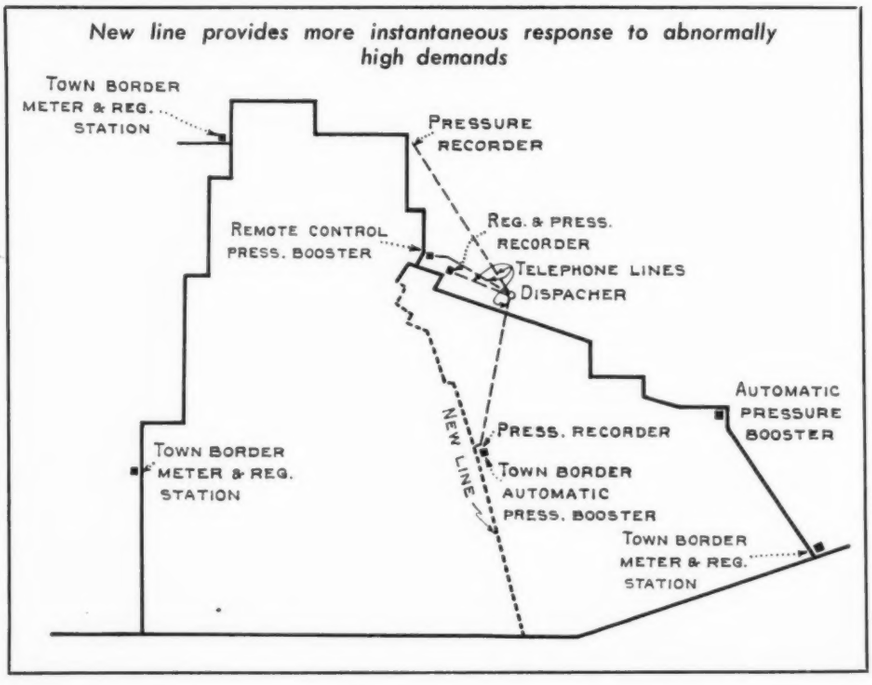
All couplings were bonded with No. 0000 copper wire and "shot points" (copper wires brazed to the pipe and



ROBERT M. HUTCHISON

is an alumnus of Pennsylvania State College—Has been affiliated with the Houston Natural Gas Company for the last 11 years—Is the developer of the Hutchison Rapid Calculator for pipe-line flow and of the H. & H. By-Pass Type Odorizer.

New line provides more instantaneous response to abnormally high demands



R.Y. SMITH
1905
This Link-Belt detachable chain was the first ever used on a rotary drillingrig Photoabove shows a drilling rig operating in the Sour Lake, Texas field in 1905, equipped with this chain.
1941
Today Link-Belt chains still set the pace for driving fast, heavy-duty rigs down to "pay."
LINK-BELT SUPER-HYPER 4 P 4

Yesterday and TODAY

● This is the story of 66 years of progress in power drives. Link-Belt began making chain in 1875, founded upon the invention of Ewart Detachable Link-Belt which was exhibited a year later at the Philadelphia Centennial along with the first "approved" bicycle. That was a long time ago . . . Edison and Steinmetz were still unknown; locomotives were crude "iron horses;" the "horseless carriage" wasn't even in the dream stage. Yes, a lot of water has gone over the dam since then and, among the great developments in this march of progress, chain drives have held no small place.

Link-Belt's Ewart Detachable Link-Belt, vastly improved over the original, served as the drive on the first rotary drilling rig. Link-Belt chain improvements have kept pace year after year with the march of progress in oil. A Link-Belt chain type and strength has met every new demand as drilling depths went deeper and drilling loads grew heavier. Yes, Link-Belt's scientific research in chain keeps establishing new highs in power drive performance and will continue to do so . . . for Link-Belt will never stop improving chain.

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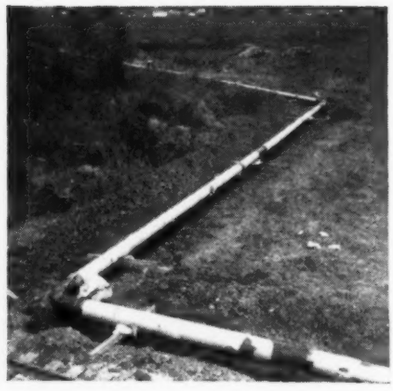
LINK-BELT CHAINS

Showing method of spanning the largest bayou on route of the new line



Relatively low pressure permits use of right-angle bends in the 12-in. section

extended aboveground) were placed at regular intervals to be used for checking current flow in electrolysis work.

To protect the pipe coating, all skids were cushioned with sand bags and all stones and hard clods were removed from the ditch bottom before the pipe was lowered.

The pipe was laid to grade in order to avoid overbending and sags. Three bayous or creeks were spanned, the pipe being supported on creosoted pile bents. Across the largest bayou, four bents were used, spaced approximately 50 ft. apart. The bents were capped with 8-in. by 8-in. timbers on top of which was placed an 8⅝-in. by 18-in. pipe nipple to act as a roller in case of any longitudinal movement of the pipe line. The pipe was placed on top of these rollers and is held in place by U-bolts that extend around the top of the pipe, pass through the roller and cap, and are bolted at the bottom. A coil spring placed between the cap and the nuts on the ends of the U-bolts allows the pipe to move without greatly increasing the stress on the bolts. To facilitate line walking and pipe maintenance, a double walkway with hand rail was built along both sides of the line, using the pipe to support the structure. A space 8 in. wide was left between the walk and the pipe in order to make the entire pipe surface accessible for painting. A gate has been placed at each end of the bridge to prevent its use by the public.

This type of pipe-line bridge is vastly different from the cable suspension structures frequently used, but it was selected because of its lower cost.

The pipe was placed on the bridge at an elevation 2 ft. higher than the high water mark and this proved to be a good precaution because shortly after the completion of the bridge, heavy rains caused flood waters to rise within 5 ft. of the pipe line.

Expansion loops built with welding ells and nipples were used at both ends of this bayou crossing. These loops were constructed on the job and connected to the ends of the bridge-supported pipe.

Valves were placed in the line at intervals of approximately 2 miles so that tests could be conducted on individual sections and the line cleaned of dust and scale as the work progressed. The line was pressure-tested with 125-lb. gas pressure and a liberal quantity of odorant was introduced to facilitate the detection of leaks.

Some unusual conditions are always encountered in the construction of city distribution mains and this line was no exception. In all, 9 paved streets and 11 railroad rights-of-way, containing one or more tracks, had to be crossed. Railroad specifications call for boring, the installation of casing and vents, and a depth of 3½ ft. below the bottom of ties. Such conditions, together with city requirements and numerous underground structures, add considerably to the cost of a project of this nature.

City construction also requires close attention to safety precautions. Deep ditches, the use of heavy machinery, the blocking of streets, and the workmen operating in close quarters creates hazards greater than usual and, in order to safeguard the public and protect the employee, safety rules must be ridgidly enforced. The company used several inspectors to insure adherence to both construction and safety specifications, a precaution well taken because no serious accidents occurred and the work on the line was well done in spite of the very adverse weather conditions that prevailed shortly after the work began.

Eleven inches of rain fell within a period of two weeks, filling the ditches with water and making the right-of-way impassable in many places. Such an abundance of water saturated the soil so thoroughly that it was necessary to wait several days after the rain had ceased before work could be resumed. Even then, a considerable amount of cleaning up and reclamation work had to be done in order to make ditching and welding possible. These difficulties, coupled with the other contingencies that always arise on any construction job, delayed the completion of the line at least 30 days. The delay could easily have been greater had it not been for the determination of the contractor and the company personnel, All "stayed right in there" as the saying goes, and, call it luck, acts of God, absence of the public enemy, or what have you, operation of the line began on December 27, rain, floods, mud, and other obstacles notwithstanding, a date in advance of the coldest weather usually experienced in this section of the country.

The most interesting feature of the new line is the method of operation, designed to be wholly automatic. The city gas station is equipped with a gas scrubber, dual meter runs on which a flow controller has been installed to insure correct measurement, an automatic booster pressure regulator, an odorizer, and a remote recording pressure gauge.

At the junction of the new line and the city loop, a remote-controlled pressure regulator has been installed. By means of telephone wires attached to this pressure control equipment, the company dispatcher in the general office can increase or decrease the flow of gas from the new line to the city loop. Remote recording pressure gauges keep the dispatcher informed of operating conditions in both the city loop and new feed line and when he makes a change at the control station feeding the city loop, the automatic booster in the town border station increases or decreases the pressure entering the new feed line in proportion to the change. This arrangement is a far cry from the old conventional type town-border station controlled manually by operators who were on duty 24 hr. every day and it is an outstanding example of the dependability of modern equipment with which it is now possible to operate a distribution system at the correct pressure at all times, thus minimizing leakage and assuring gas consumers a sufficient dependable supply of fuel, regardless of weather conditions.

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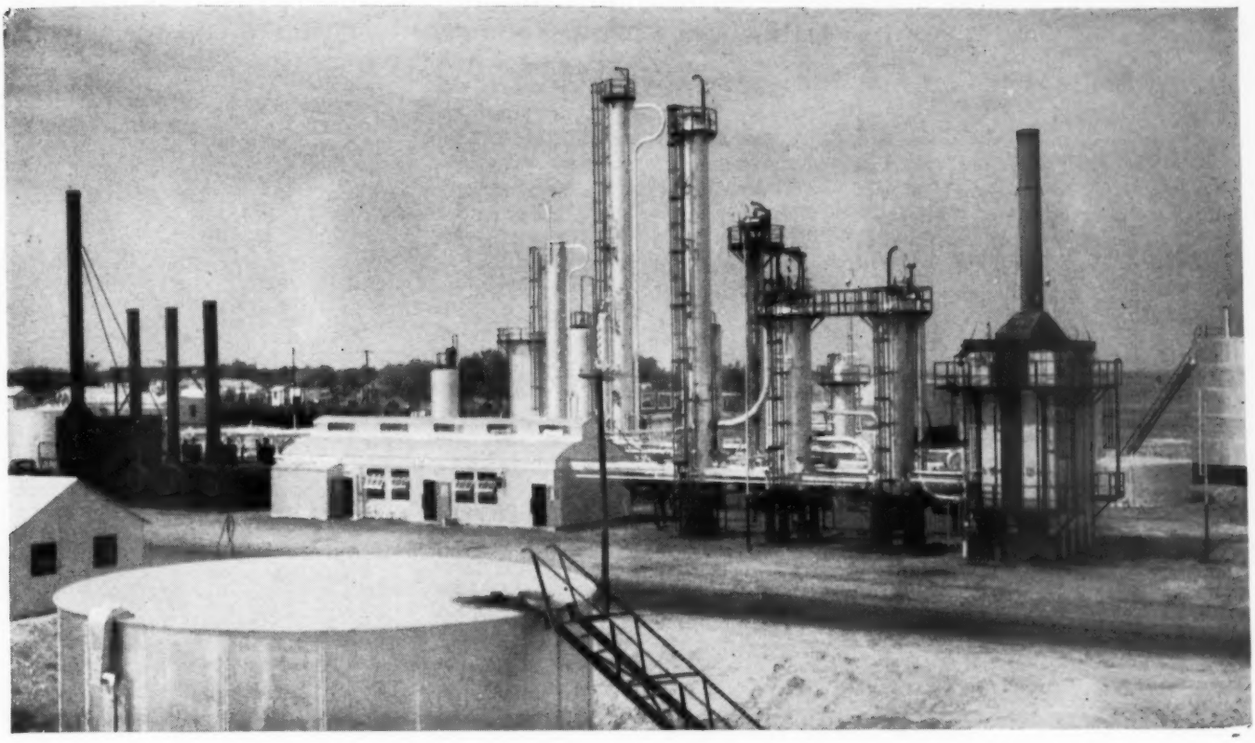
P 724.



General view of Malco Refineries, Inc., plant at Artesia, New Mexico

Refining Mixed-Base Sour Crude Oils in New Mexico

PETROLEUM ENGINEER Exclusive Feature

☆ Operating data, based on year's record rather than on favorable test data, show remarkably high liquid yields in Artesia refinery

by J. C. Albright

IN MANY reports written to describe the operation of a refinery, the analysis is usually based on a selected run, or a special day when conditions were more favorable to the process than some other day, and which therefore do not show what the plant will accomplish over a long-time period, as during a complete year for example. What any refinery will accomplish, when processing the run-of-the-mill type of crude, will be shown more clearly when the yields are computed of all the products obtained from a large quantity of charging stocks. During the year 1939, Malco Refineries, Inc., at Artesia, New Mexico, processed nearly 500,000 bbl. of eastern New Mexico crude oil, producing 57.17 percent of 400-endpoint gasoline, with an overall processing loss, including uncondensable gases, of only 7.85 percent, which indicates that the plant had a liquid recovery of 92.15 percent.

This plant had its inception as a simple skimming unit, constructed and placed in operation several years before the race for higher octane gasoline began. This plant, however, was modern in every respect with a tubular heater, fractionating columns, and side strippers for heavier products, such as kerosine and furnace oils. The crude oil available for processing was, and still is, produced in the Mescalero Sand

J. C. ALBRIGHT

was drilling superintendent for H. J. von Hagen in North Texas area, 1919-1921—With the Noble Oil and Gas Company, Burkburnett, Texas, from 1921 to 1923—Joined staff of the Dixie Gasoline Company in 1923 and became Texas manager—Employed by Phillips Petroleum Company in 1925 and was sent to New Mexico, where the company constructed a natural gasoline plant—Left Phillips in 1929 and for a time operated as a consulting engineer—For last 12 years has devoted virtually all his time to free-lance writing for trade journals.

area of eastern New Mexico, west of the high plains escarpment, or Cap Rock, and east of the Pecos River. Most of the crude oil in this area is of mixed-base and is quite sour, containing sulphur compounds, such as hydrogen sulphide, and, also, the gasoline and pressure distillate fractions contain mercaptans, not easily converted by the common methods of treating, such as with doctor solution and hypochlorite. Common salt is also contained in most of the oil, part of which is removed in the field but a considerable quantity still remains in the crude oil when it is received at the refinery. Most of this salt is removed by heating and settling in two large drums, so that, at the present time, corrosion is of no particular consequence, and mechanical plugging of tubes in the heaters has been eliminated.

The skimming section of the refinery consists of a tubular heater and exchangers to conserve the heat with double flashing of the charge in two towers consecutively. The crude is picked-up from storage and passed through adequate exchangers, countercurrent to product vapors and fuel oil (topped crude) when it enters the primary column so that a quantity of the more volatile fractions is released before the commodity enters the tubular fired heater. From the base of this primary flash column, the partly topped crude is pumped to the pipe still to be heated for the recovery of additional gasoline (or naphtha), gas oil, and kerosine.

The topped crude, having a gravity of about 23° A.P.I., is sent to storage, or pumped directly to the cracking still from the base of the second flash column. The topped crude charge pump (7½ by 5 by 6) for the cracking plant is a duplex unit, handling an average volume of 830 bbl. per day. The topped crude enters the main fractionating column above the second stripping plate. There are seven plates in this 4-ft. by 48-ft. fractionating tower, which is operated at a pressure of 70 lb. gauge. Recycling stock and topped crude in process collect in the base of this column at a temperature of 675°F. From the column the material is pumped to the cracking furnace by a 4½ by 12 duplex plunger packed hot-oil pump, driven by a Diesel engine.

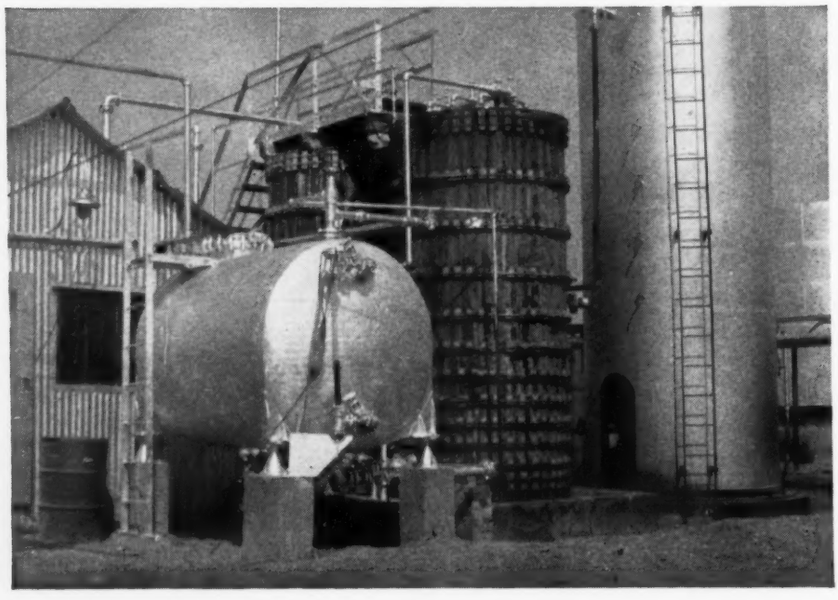
The furnace is an up-shot, counterflow heater, containing 50 radiant tubes arranged in a double row in the center of the unit, and 48 convection tubes suspended in the upper section below the stack. The flow of the material is from top to bottom, with a cross-over temperature of 765°F. maintained, so that, when the commodity enters the transfer line, the temperature is consistently 935°F. A 2½-in. insulated transfer line carries the material from the furnace to the top of the reaction chamber, having a diameter of 42 in., a height of 25 ft., and 2½ in. walls. This vessel is operated at a pressure of 290 lb. gauge. All material leaves the base of the reaction chamber through an extra-heavy 2-in. line to enter the 5-ft. by 24-ft. flash chamber. Material entering the flash chamber has a temperature of 835°F., and the liquid draw-off at the base has a temperature of 800°F. Vapors from the top outlet

Main and flash columns in skimming plant

are maintained at a consistent temperature of 760°F. with a controlled quantity of cooling oil acting as a wall-wash.

Vapors from the flash chamber enter the main fractionating column below the seven stripping plates, so that the heat will be partly imparted to the descending topped crude falling from the second plate to the base. The principal product derived from the vapors entering the main fractionator is pressure distillate, although part of the light oil accumulating in the tray above the thirteenth bubble plate is frequently drawn-off as a component of Diesel fuel. This light oil reservoir is usually maintained at a temperature of 450°F. by returning part of the cooling oil to the column on the ninth bubble plate. The overhead of the main column is held at a temperature of 400°F. with reflux pumped from the base of the pressure distillate receiver by a 6 by 5¾ by 6 duplex steam pump. The amount of reflux is controlled by a recording temperature controller acting on the steam supply at the pump with the thermometer well on the vapor line a short distance from the vapor outlet. A temperature

Copper-sweetening plant for removal of hydrogen sulphide from gasoline



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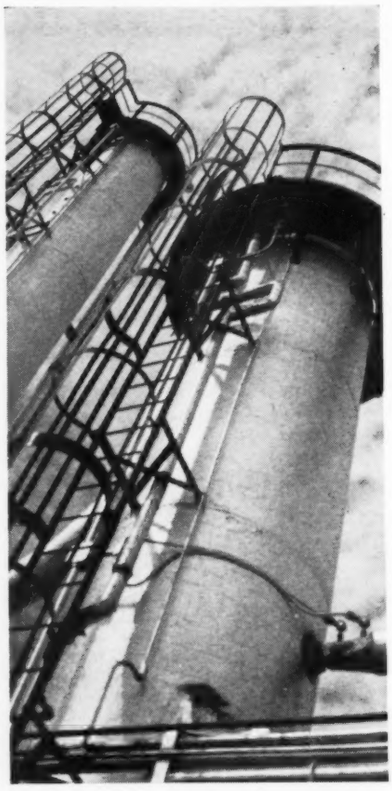
of 400°F. is established at the vapor outlet so that the condensate will have the desired end point after stabilizing for vapor pressure control.

The cracked gasoline vapors pass through clay towers placed in the line between the main fractionator and the vapor condensers so that gums will be removed. The accumulated polymers from the base of the clay towers are pumped back to the system to be reprocessed with the topped crude charge. The vapors from the clay towers pass through a series of submerged pipe condensers, containing 2500 sq. ft. of exchanger surface so that the liquid will have a temperature of approximately 75-80°F. The reduction of temperature between the vapor outlet and the pressure distillate receiver is approximately 325-330°F., as the vapors from the vapor outlet and the base of the clay towers have been reduced only about 15°F.

The end-point pressure distillate is stabilized continuously by pumping from the receiver with a duplex steam pump through finished gasoline-to-charge exchanger having 240 sq. ft. of surface and thence to the column on the fifteenth plate. The 2-ft. by 44-ft. stabilizer contains 24 bubble plates and a reboiler at the base having 110 sq. ft. of heating tubes. The reflux condenser is placed at the top of this column and contains 250 sq. ft. of cooling surface, which is controlled with water pumped through the tubes to hold a temperature of approximately 95°F. at the dry gas outlet. Stabilized pressure distillate passes from the base of the column at a pressure of 132 lb. through the feed heater and an after-cooler having 120 sq. ft. of surface.

The product removed from the light oil reservoir in the main fractionating column is passed at system pressure of 72 lb. through the pressure distillate fractionator reboiler to maintain a temperature of 310°F., after which it flows through a series of coolers containing 1000 sq. ft. of surface. From this point it is pumped with a 6 by 5¾ by 6 duplex steam pump to the top plate of the 2-ft. by 33-ft. vapor absorber, which contains 16 bubble trays to contact the gas flowing from the pressure distillate receiver, and is operated at a pressure of 53 lb. gauge.

This oil, containing absorbed gasoline, is pumped from the base of the absorber to several points in the plant for temperature control. Part of it enters through a 3-in. line between the reaction chamber and the flash chamber, and part is distributed as wall wash in the flash chamber and to control the temperature of the vapors leaving that column. Another portion enters the main fractionating column above the eighth bubble plate to control processing temperatures.



Safety ladders protect the operators who must climb to top of columns

Over the relatively long period of time represented by the 259 working days in 1939, the plant operated as shown in Table 1.

TABLE 1

	Percent	Bbl.
Fresh crude charge	100.00	494,353.00
Overall gasoline produced	57.17	282,621.61
Kerosine and distillate	9.49	46,913.20
Gas oil	5.84	28,872.22
Fuel oil	19.65	97,140.36
Gas and loss	7.85	38,805.61
	100.00	494,353.00

During this same period, the cracking section of the plant, charged with topped crude from the skimming section, operated as shown in Table 2.

TABLE 2

	Percent	Bbl.
Topped crude charge	100.00	215,056.00
Cracked gasoline produced	52.78	113,506.56
Industrial fuel oil	40.60	87,312.74
Gas and loss	6.62	14,236.70
	100.00	215,056.00

Tables 1 and 2 indicate that the liquid recoveries in the plant as a whole were 92.15 percent; in the cracking plant, 93.38 percent.

In common with the crudes produced in West Texas and eastern New Mexico, Artesia crude produces a gasoline containing both H_2S and mercaptans. The gasoline is processed for the removal of H_2S with an aqueous solution of NaOH circulated with the product through a vertical column from which the gasoline leaves at the top to enter a quiescent period in an adequate settler so that the solution in suspension can drop out before the commodity is treated for the conversion of the mercaptans.

The gasoline produced at Artesia until recently had been treated by the customary methods, including simple doctor solution, but now a system is in use that employs a liquid phase of copper sweetening. The gasoline after H_2S removal is pumped with the reagent into a glass-lined horizontal contactor in which the mercaptans are oxidized to disulphides by cupric chloride; the cupric chloride is reduced to cuprous chloride and hydrochloric acid. The gasoline passes from the glass-lined vessel to storage, and the cuprous chloride flows to a wooden tank, where it and the hydrochloric acid are regenerated to cupric chloride by bubbling air through the liquid from a submerged spider on the floor of the vessel. By this method of treating, it is said that the gasoline is not reduced in octane value, and at the same time susceptibility to tetraethyl lead is increased.

High-Wage Rates in Refining Industry

Highest average hourly entrance pay rate for common laborers in any of 16 manufacturing industries surveyed is found in petroleum refining, it is reported in the U. S. Department of Labor's "Monthly Labor Review." The average for petroleum refining, 63.6 cents per hour, was 13.8 cents greater than the 16-industry average of 49.8 cents per hour.

The report indicates that petroleum refining led not only in the general average, but in every section studied. Within the northern and western regions, where the average was 56 cents per hour, petroleum refining averaged 67.4 cents. In the south and southwestern regions, where the average was 35.5 cents per hour, petroleum refining averaged 57.9 cents per hour.

A survey of 20 industries revealed that in the northern and western regions the petroleum refining industry stood alone in paying virtually all common laborers 40 cents or more per hour. In the south and southwestern regions petroleum refining had the highest concentration in the upper brackets, more than 98 percent of common laborers receiving entrance pay of 40 cents or more per hour.

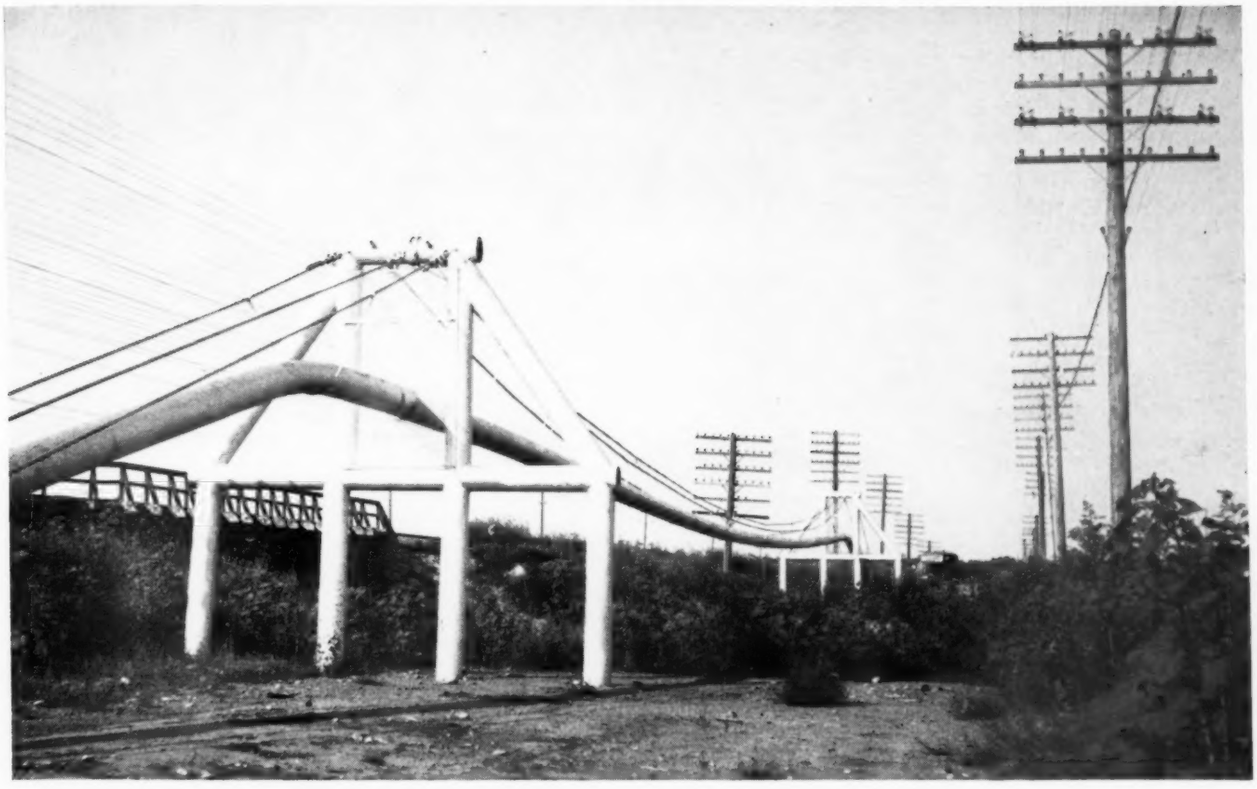


Fig. 1. The banks of this creek were undercut so often and so rapidly that the suspension bridge shown here proved the only solution to a difficult problem

Pipe-Line Crossing of Swift Watercourses

PETROLEUM ENGINEER EXCLUSIVE Feature

☆ **In semi-arid areas subject to severe erosion suspension bridges are vital to uninterrupted operation**

by J. E. Moore

Vice-President, Billings Gas Company,
Billings, Montana

J. E. MOORE

for 19 years has been in the employ of various gas companies affiliated with The Ohio Oil Company — He spent six months in the natural gasoline department of The Ohio Oil Company, for three years was local manager of The Rocky Mountain Gas Company in Wyoming, having added duties in care of field gas-measurement and pressure-control equipment in Big Horn Basin fields, for four years was superintendent of distribution for the Billings Gas Company, superintendent of pipe lines for Gallatin Natural Gas Company, and from 1929 to 1933 was manager of the Billings Gas Company and superintendent of the Gallatin Natural Gas Company — Since 1933 he has been vice-president and general manager of the consolidated companies.

MANY of the western oil and gas fields are situated in semi-arid areas wherein pipe lines must traverse sections subject to severe erosion. Torrential downpours in these areas coupled with rapid run-off eat away the loosely consolidated soil like so much sugar. Watercourses that normally are dry or contain only a trickle of water may be transformed almost instantly into raging torrents. Stream beds shift with each succeeding flood, gentle slopes may suddenly become deep-cut banks, and pipe lines that were thought to be safely buried may be left hanging in the air or be entirely carried away.

Streams that have their origin in the mountains and are fed by melting snows are subject to seasonal but often prolonged floods that not only scour and gouge the steeply sloping channels and tear away the confining banks, but make it extremely difficult to repair any damage to pipe lines crossing

them until the floods have subsided, often many weeks later.

Inasmuch as pipe-line repairs cannot wait, and the very nature of their use requires that interruptions in service be avoided at all cost, there has been a constant effort on the part of pipe-line operators to devise better and more nearly trouble-free methods of carrying their lines across the many relatively small but extremely troublesome watercourses. The requirements for such crossings are that they be inexpensive, readily constructed by regular pipe-line crews, use ordinary and readily available materials, and be so designed that a considerable amount of shifting and deepening in the stream bed can occur without impairing the strength and safety of the crossing itself.

These requirements are met to a very satisfactory degree in a type of suspended span developed by a natural gas company operating in Montana and Wyoming. There is nothing new or unusual in the general idea, but the use made of every-day materials and the construction methods used may be of some interest to others with similar problems.

An example typical of shifting and deepening channels is found in the creek spanned by the structure shown in Fig. 1. At this point the creek traverses an extensive "bench" in the valley of the Yellowstone River. Its normal flow is almost nil, but the drainage area is large and even moderate rains cause severe floods. Three highway bridges have been carried away at this point during the last 15 years, and the stream bed has shifted back and forth. The topsoil, blanketing the area to a depth of many feet, is a sandy loam carried down from the neighboring hills, a very difficult type of soil to "tie down."

The pipe line that runs under this creek is buried to a depth of 12 ft. in the approaches, yet these banks have been undercut so rapidly (in a few minutes' time) that 50 ft. or more of the line has been left hanging and exposed to the full force of the flood.

Fig. 3. A typical highway crossing span

To avoid the hazard of interrupted service that might follow a repetition of this experience, the span shown was constructed as an additional crossing and tied-in some 800 ft. back from each of the present creek banks.

To provide for the usual amount of shift in the channel, the supporting piers or frames were set back some 50 ft. from the banks, making a clear span of 175 ft. Anticipating the possibility that the channel might shift farther than had been expected and undermine the supports, the foundation pipes were driven several feet below the creek bed.

Junked 8-in. pipe was used for the supports in this job, and the supporting cables are from a discarded drilling line. The suspenders are made of telephone guy wire with the ends "raveled" and carefully wrapped around the cables. The frames are guyed to pipe "deadmen" anchored in concrete, and the guys are entirely independent of the suspension cable, each having its own means of tightening.

In designing the span, allowance was made for a certain amount of sag, the high points on the pipe being directly under the high points on the suspension cable, so that the forces of contraction and expansion, due to the changing temperatures, are always working in unison as between the pipe and cables, instead of in opposition as would be the case if the pipe were level or arched in the center. The pipe does not rest on a solid support at any point, nor are there any suspenders directly under the end frames. The predominant idea in the design is to have the entire span as resilient as possible so that the pipe acts in the manner of a huge spring in accommodating itself to the strains of expansion and contraction.

Fig. 2. Looking across Clarks Ford River, a rapid mountain stream

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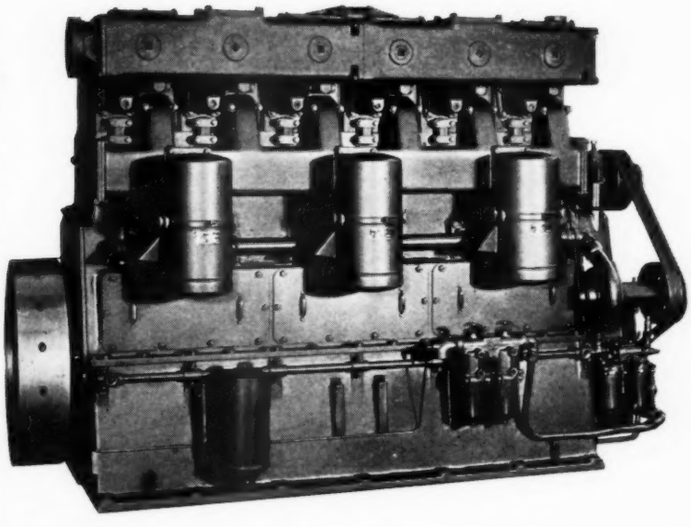

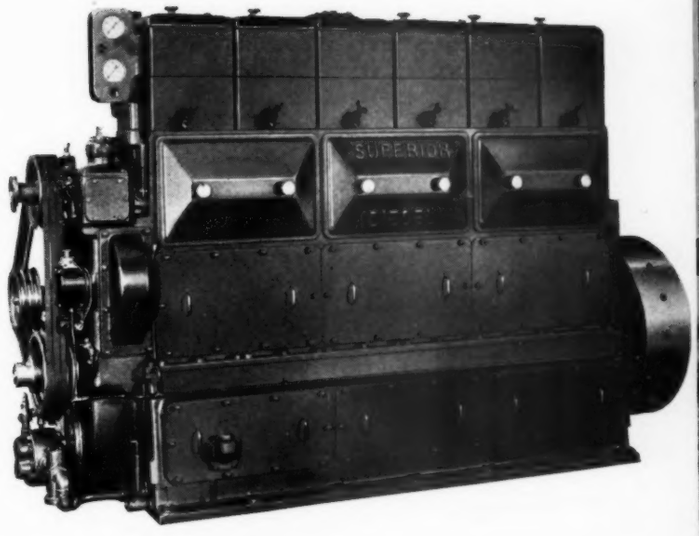

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Fig. 4. A pile driver mounted on a pipe-line maintenance truck is a valuable piece of equipment in construction of suspension bridges

Where soil conditions are bad and pipe piling is apt to deteriorate rapidly, the pipe posts are filled with concrete after they are driven and the guy cables are sheathed in 2-in. or 3-in. pipe, the lower ends of which are embedded in the concrete anchor blocks, the tops extending above the ground, and the pipes are then filled with asphalt.

In carrying a pipe line across a stream that has relatively firm banks, the supporting pipe frames may be set in concrete bases, and when the line does not rise too much to the crossing, the anchor blocks or deadmen may be dispensed with and the guy cables attached to strong clamps bolted around the pipe line itself at a proper distance. These clamps are best placed back of a weld bead to avoid slipping, and so placed, provide a very good attachment for the guy cables.

As stated before, there is nothing new or unusual about the idea of suspending pipe lines across water courses, but in working out the structures described an effort has been made to limit the materials and equipment required to those readily available. Every pipe-line concern has old pipe suitable for piers or supporting frames. Some sort of cable or old drilling line is nearly always to be had. Suspenders may be made from telephone guy cables or they may be twisted on the job, using No. 9 galvanized wire. An easy and quick way of doing this is to loop the wire around two sticks, attach one stick to a rear wheel of a truck that has been jacked up, and have the wheel turned slowly in low gear while the other stick is held to keep the wires taut.

The pipe posts may be driven by means of a pile-driving device attached to the rear of a maintenance truck and operated from the truck winch. The one illustrated is made of small drill pipe and tubing, the hammer being a discarded 15-in. drilling bit with a short piece of sinker welded along each side to increase the weight, and with guides made of 4-in. pipe split and welded to the hammer to form channels.

By hooking the hammer to the side frames, the whole device can be picked-up for moving by tightening the winch line and can then be set down ready for the new piling. Vertical alignment is obtained by moving the truck forward or backward. This same pipe-driving attachment finds many other uses in pipe-line maintenance. It can be used for placing ground-beds used in cathodic protection work, in construction of bridges along rights-of-way, and in riprapping cut banks. It is easily attached and fully portable and can be built in any shop equipped for welding.

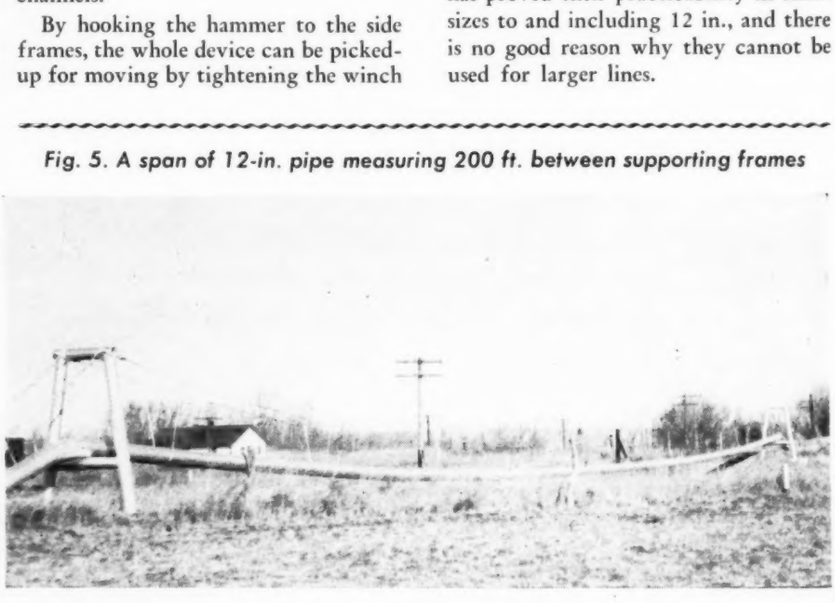
In constructing and placing the pipe span, a snatch block is used as a trolley running on the cable above to carry the front section of pipe while it is pulled across with a winch line, the pipe being welded on a section at a time. Chains are used for temporary suspenders during placing of the pipe, after which pipe and cable are brought to their desired positions by means of a light hoist, preferably of the lever type, or a fence jack.

Crossing spans of the type described are not confined to stream beds, but provide a ready means of carrying pipe lines across deep highway cuts where a buried crossing would entail difficult construction and maintenance. Such spans of more than 200 ft. in length are now in use, crossing state highways with the approval of the highway engineers.

When suspended crossings are near places frequented by children, heavy wire screens may be placed in the supporting frames to prevent anyone walking or crawling out on the pipe and falling off.

Use of such spans over a period of several years, in a climate subject to extreme changes of temperature and where high winds are not infrequent, has proved their practicability in small sizes to and including 12 in., and there is no good reason why they cannot be used for larger lines.

Fig. 5. A span of 12-in. pipe measuring 200 ft. between supporting frames



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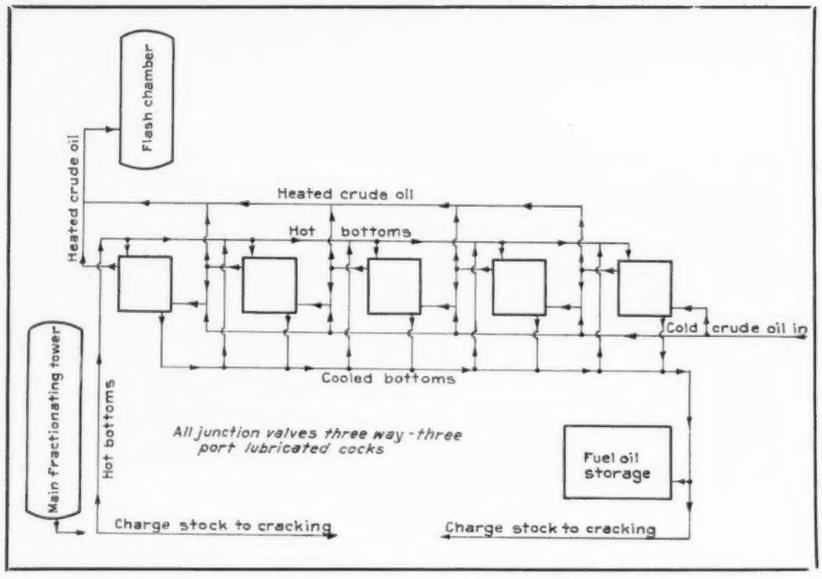

Fig. 1. Primary heat exchanger manifolds designed for maximum utility

PETROLEUM ENGINEER Exclusive

by R. G. Lovell

Development Engineer, Hancock Oil Company of California

Refinery Piping . . . Design of Line From Charging Pumps to Flash Towers

☆ Liberal number of valves recommended to increase flexibility in manifolds

IN THE layout of the line from the primary charging pump through the heat exchangers to the flash towers there are many opportunities to effect marked increases in operating efficiencies by the use of methods and materials that would have the reverse effect in the design of other refinery lines. For example, if the suction line from crude oil storage to the pump has been designed so that no vaporization occurs in the line, no particular thought need be given to ameliorate its effects on the discharge side of the pump. This permits the discharge line to be designed so that it can perform its functions properly and at lower initial cost than if the effect of vaporization had to be considered.

In order that this relatively complex calculation can be made more simple we will consider the proposition as having three sections: First, the line from the pump to and through the cold crude oil manifold at the exchangers; second, the flow through the exchangers, and third, the hot crude oil manifold and thence to the evaporator.

Because a centrifugal pump does not have the same ready response to changed flow conditions as the displacement type, it is not generally used for this duty. As increased head-loss-due-to-friction is reflected only in greater power demand and no change in volume capacity when a displacement pump is used, the penalty to be paid for small line size is not great. Further, for reasons of dependability and ease of control, the steam-driven reciprocating pump is in general use. Steam costs in a refinery are usually low so that power for this pump is not a matter of great importance.

Careful thought given to the design of the cold crude oil manifold at the exchangers can return substantial dividends in the form of more flexible control of volumes and temperatures. This is becoming more important now than ever before for a reason that should be clearly understood. During the early development of cracking no particular effort was made to conserve the heat in either the straight-run bottoms or the gas oil in charging them to a cracking plant. Everyone was thinking primarily of working the "bugs" out of his cracking process. Fractionating tower bottoms were sent through the primary heat exchangers in order to raise the temperature of the cold crude oil to the point desired for flashing and the hot bottoms were thereby reduced in temperature. The control, necessarily, was the proper outgoing temperature of the crude oil. When this point was reached the excess amount of hot bottoms went

R. G. LOVELL

received his academic training in New York and served several of the larger mining and milling companies of New Mexico, Arizona, and the Republic of Mexico as power engineer and master mechanic from 1908 to 1917, then saw military service in the engineering corps until 1919 —Returning from the war he became affiliated with the oil refining industry, first with Standard Oil Company of California as refinery construction engineer and later with a foreign company —Later he was made assistant to the chief engineer of Pan American Petroleum and Transport Company for the construction of their California processing properties—He has been with The Hancock Oil Company of California since that time—Lovell is the senior instructor of the class in practical petroleum refining, which he organized some seven years ago, for the Trade Extension Division of the Long Beach High Schools—The class is attended by employees of the many companies operating in the southern California fields.

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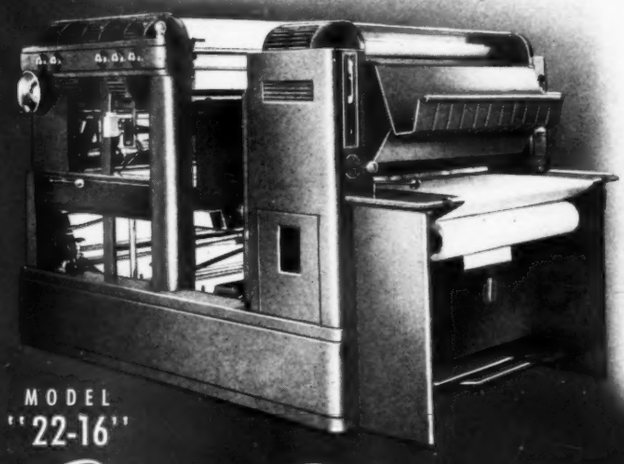

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directly to storage with the inevitable result that a temperature dangerously greater than the flash point of the oil could, and did, sometimes exist. Later practice was to charge some of this material directly to cracking. With all the variables of supply and demand, volumes, and temperatures it was almost impossible to control all these conditions as closely as desired. No great importance was attached to saving heat as there always seemed to be so much excess heat in the cracking process that there was little point in taking any trouble to conserve it. Perhaps the best excuse for this seeming waste was that the fixed gases in considerable volume produced in the cracking operation were so corrosive that they could not be marketed and were, therefore, burned in a flare or were used under boilers and stills. These gases are high in heat content and there was not much incentive to save heat from other sources while this was being wasted. With the advent of polymerization and alkylation all this has been changed. These gases are now of distinctive value as charging stock in both processes.

With the foregoing in mind we shall endeavor to design the manifolds for incoming cold and outgoing hot crude oil, as well as the manifolds for both hot incoming and cooled outgoing fuel oil. Utility will be the major object rather than low friction loss.

The values of friction loss in pipes, as shown in Table 1, are sufficiently accurate for this purpose. Although it does not extend to 300 gal. per min., which is the equivalent of the specified duty of 10,000 bbl. per day assumed as the load on the line, interpolation shows that the line loss would not be more than 3 lb. per sq. in. per 100 ft. for 4-in. pipe. With liberal additions for fittings this loss would not exceed 5 lb. per sq. in. per 100 ft., which is entirely in order. In cases of this kind when the line is relatively short, one can be guided by the size of discharge outlet on a displacement pump of proper capacity rating.

The illustration (Fig. 1) shows how the ultimate in flexibility and utility can be obtained. First glance at the drawing would seem to indicate that the cost of valves and fittings and their installation would be very high. The total cost would, of course, be considerably higher than for the conventional method but the returns in continuity of service and adaptability to widely varying operating conditions will justify the extra cost. Use of flanged valves and welding fittings throughout will make for convenience of construction, insurance against leaks, and will simplify later changes. No fear need be entertained regarding temperature stresses in these manifolds as their complexity adds to their capacity to absorb such strains. If the job is welded throughout, mild steel flanges and lightweight pipe may safely be used. Of course, no cast-iron fittings should be used.

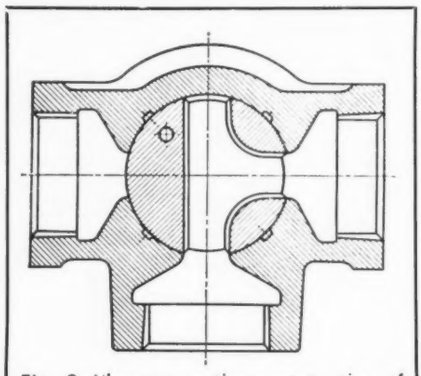

Fig. 2. Three-way, three-port valve of the type referred to in Fig. 1

Careful analysis of the sketch will show that any one or more of the units can be isolated from the others without interruption of service. Thus periodic cleaning can be carried on by working one unit at a time with the others carrying the load. Maintenance of clean surfaces in heat exchangers by whatever means are required by service conditions and nature of the oils will, in most cases, make possible a substantial saving in original cost of the heat exchanger equipment.

Another very important advantage is the ability to repair or replace tubes without shutdown. Standard practice is to run crude oil through the tubes and the hot bottoms around them for reasons of pressure. A leak, therefore, causes crude oil to pass to fuel. Its presence is detected by low flash point of the fuel oil. The potential fire hazard of this condition is obvious but the hazard is sometimes accepted for some period of time to avoid complete shutdown. With the manifolds as shown and with sample cocks provided at each unit the individual exchanger causing the condition can be identified and taken out of service for repair.

In most refineries the heat balance in these exchangers is nearly always on the plus heat side. The control point is the top temperature to which the raw crude oil can be brought for flashing without sacrifice of desirable low end-point and chemical quality of the flashed overhead stock. This temperature is seldom above 250°F. and despite the fact that there is a greater volume of crude oil to be heated than there are bottoms with which to accomplish the heating, the wider desirable temperature range of the bottoms (approximately 430°-250°F.) usually leaves an excess of heat in the bottoms to storage. In plants where this heavy oil forms a part of the cracking plant charge it is obviously an advantage to

TABLE I

Friction loss in pipes handling oil

Flow g.p.m.	Pipe size, in.	Viscosity in Saybolt Universal seconds												
		30	35	40	50	60	80	100	200	300	400	500	1000	1500
30	1½	6	7	8	10	11	12	13	16	20	25	30	59	88
30	2	2	2	3	3	3	4	4	5	6	8	11	22	32
30	2½	1	1	1	2	2	2	3	3	4	4	5	11	16
40	1½	10	12	14	16	18	19	21	25	30	35	40	78	117
40	2	3	4	5	6	6	6	7	8	10	12	15	28	42
40	2½	1	1	2	2	2	3	3	4	5	6	7	14	21
50	2	5	5	7	8	8	8	9	11	13	15	18	36	55
50	2½	2	2	3	3	3	4	4	5	6	7	9	18	26
50	3	1	1	1	2	2	2	2	2	3	3	4	8	12
60	2	7	7	9	10	11	12	13	16	18	20	22	43	65
60	2½	3	4	4	5	5	5	6	7	8	9	11	23	32
60	3	1	1	1	2	2	2	2	3	3	4	4	9	14
80	2	11	13	14	16	18	20	22	26	30	32	35	58	86
80	2½	5	5	6	7	8	8	9	11	13	14	16	28	43
80	3	2	2	2	2	3	3	3	4	5	5	6	12	18
100	2½	7	8	9	10	11	12	14	17	19	21	24	36	55
100	3	2	3	3	4	4	4	5	6	7	7	8	15	22
100	4	1	1	1	1	2	2	2	2	2	3	3	5	7
140	2½	13	15	17	19	21	23	25	30	34	36	39	49	74
140	3	5	6	6	6	7	8	9	10	12	13	14	21	32
140	4	1	1	2	2	3	3	3	3	3	4	4	7	11
160	3	6	7	8	8	9	10	11	13	15	16	17	24	36
160	4	2	2	2	3	3	3	3	4	4	5	5	8	12
160	6													
200	3	9	10	11	12	14	15	17	20	22	24	26	32	44
200	4	2	3	3	4	4	4	5	6	6	7	7	11	15
200	6													

Remarks: This table shows the head in feet of water necessary to force oils of various viscosities through 100 ft. of new standard wrought-iron pipe.

Specific gravity equal to unity applies to this table.

When the density is other than unity, multiply the head found in this table by the specific gravity and the result will be head in feet of water corrected for specific gravity.

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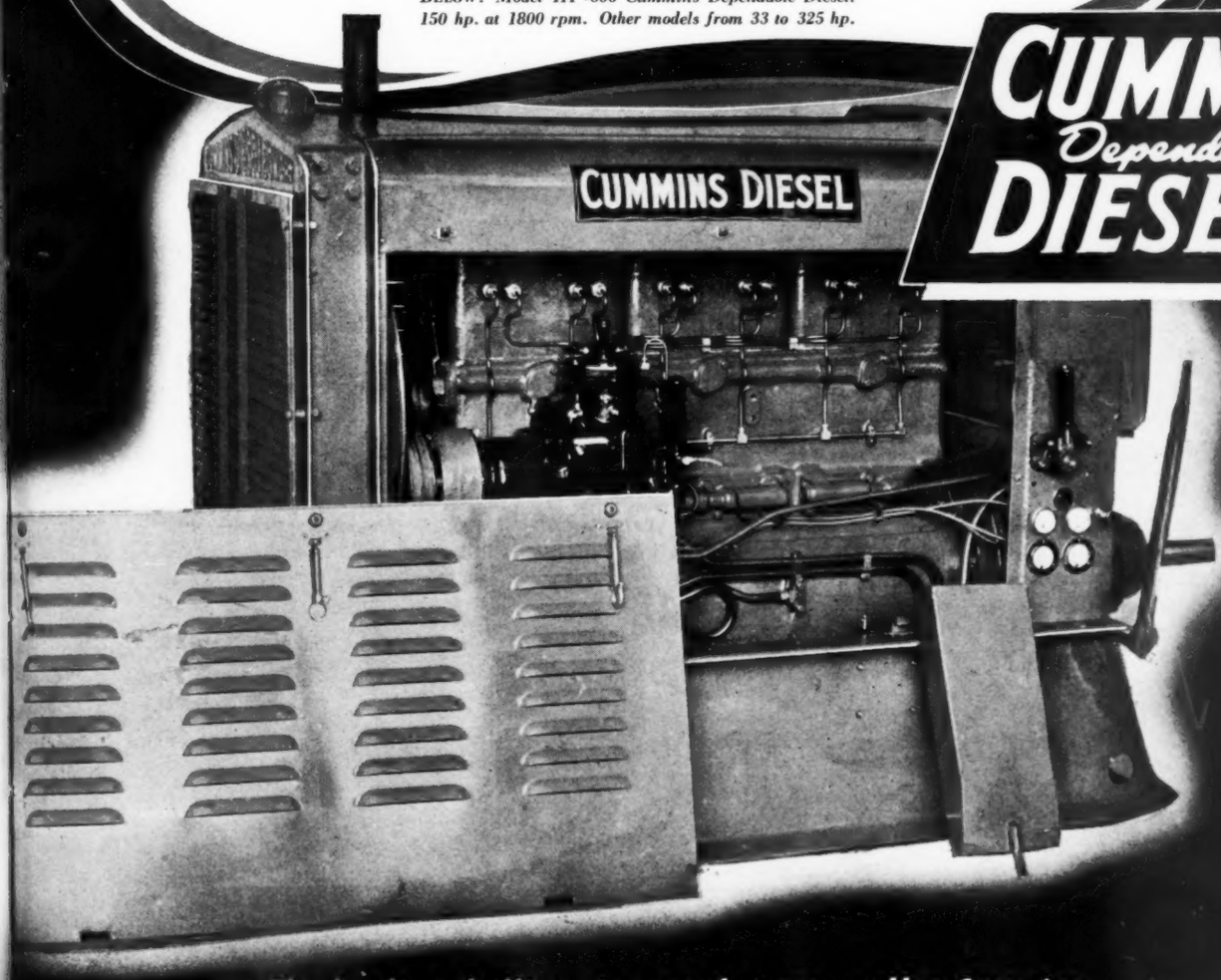

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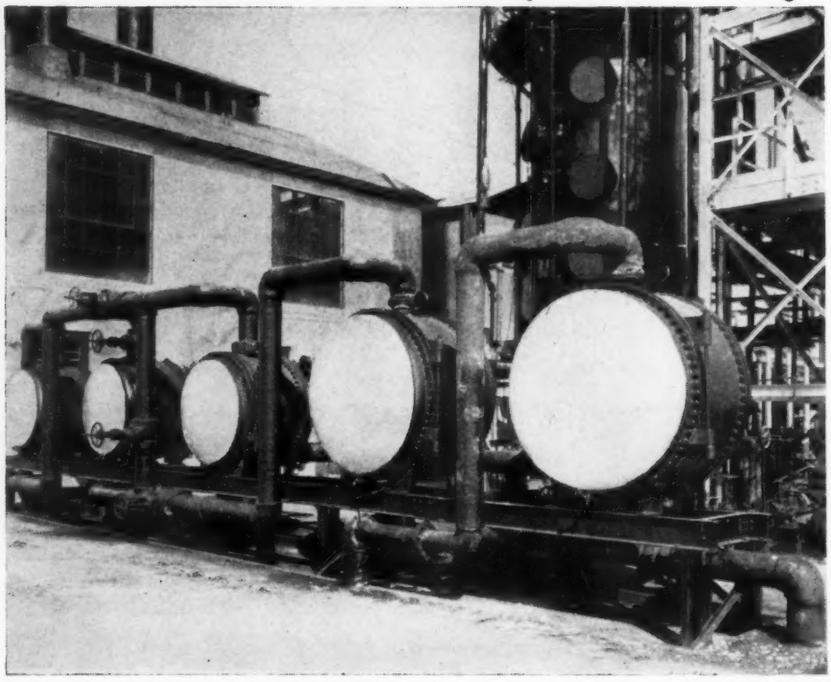

Fig. 3. Heat exchangers installed in a modern refinery

be able to draw as desired from this heavy oil without reduction in its temperature. Study of the proposed plan will indicate how easily and simply this can be done. In fact, by a few simple branching connections, the units can be operated partly in multiple and partly in series. Liberal placement of thermometer wells will facilitate this and leave no need for manipulation by guess.

Exchanger Flow

As previously pointed out, there is no valid reason for seeking to attain the minimum pressure drop in this circuit. Further, it must be kept in mind that low velocity, either through the exchanger tubes or around them, is bound to defeat the efficiency of the body as a heat exchange unit. The units shown in the accompanying photograph (Fig. 3) were designed for the capacities used in this series of articles. The pressure drop through each of them, when all are connected in series, averages 13 lb. per sq. in. The total pressure on the pump is 70 lb. per sq. in., which checks with the figures heretofore given.

In conclusion the writer wishes to leave the thought that the general plan as outlined can be adapted to a wide variety of plant capacities and other conditions. Especially it should be noted that, for plants smaller in capacity than the one specified, advantage will be found in increasing the number of tube passes and without imposing undue load upon the pump. The penalty to be paid for increasing the number of *shell* passes is only in the form of possible suction difficulties at the pump, which is forcing the hot bottoms through the shells of the exchangers.

A future article will discuss the lines involved in taking suction on the bottoms of the primary flash chamber and forcing the oil through the tube heaters and into the main fractionating tower. Several new factors that are directly concerned with processing practice will be encountered and the writer shall try to show how these factors can be met and overcome in practical and efficient manner.

Nation's Petroleum Reserves Increased Half-Billion Barrels

AN ESTIMATED increase during 1940 of more than a half-billion barrels in the proved petroleum reserves of the United States, lifting the January 1, 1941, total to a new high of 19,024,515,000 bbl., is reported by the American Petroleum Institute's Committee on Petroleum Reserves.

The committee ascribes the increase of 541,503,000 bbl. over the 18,483,-012,000-bbl. estimate of January 1, 1940, to discovery and development by the petroleum industry of 1,893,-350,000 bbl. of new reserves as compared with 1940 production of 1,351,-847,000 bbl. of crude oil.

The new total is said to include all grades of crude oil and distillate known to be recoverable under existing economic and operating conditions, but does not include reserves that may be found in favorable areas as yet untested. Explaining that the estimates refer only to reserves actually proved by drilling, the report says that pools tested by one or two wells have been assigned low reserves that may be considerably augmented by later development, a source of new oil regarded as equally important as the original discovery of the field.

Thirteen of the 23 oil-producing states discovered or developed more oil than they produced in 1940, the report indicates, and with the sole exception of California proved reserves of every oil-producing state were increased by discoveries and by upward revision of earlier estimates in the light of new developments. Texas made the largest gain in reserves, 1,348,271,000 bbl. in 1940, and now is estimated to have the largest reserves of any state, 10,623,516,000 bbl. Surprisingly large gains were reported from some states. Among these were New York, with reserves estimated at 65,001,000 bbl. as against 35,392,000 a year ago; Nebraska, with 3,749,000 bbl. as against 50,000, and Mississippi, with 40,242,-000 bbl. as against 6,642,000.

"It should be comforting to the American people to know that in times like the present, with war clouds hanging low over the world, the American petroleum industry has discovered and developed more oil in this country than has been produced," commented Institute Executive Vice-President W. R. Boyd, Jr., in receiving the committee's report from Chairman J. Edgar Pew, Sun Oil Company, Philadelphia, Pennsylvania. "This report, which is based upon the studies of reliable American petroleum geologists and engineers, indicates that for the fifth consecutive year the petroleum industry has increased the nation's crude-oil inventory. No other nation can boast such a record, nor enjoy the satisfaction of knowing so much oil is available."

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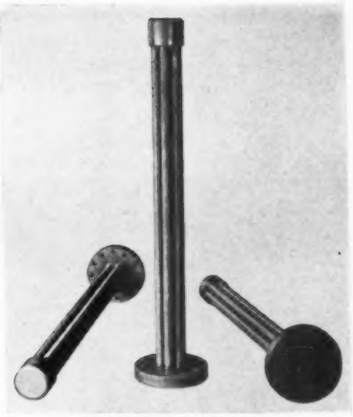

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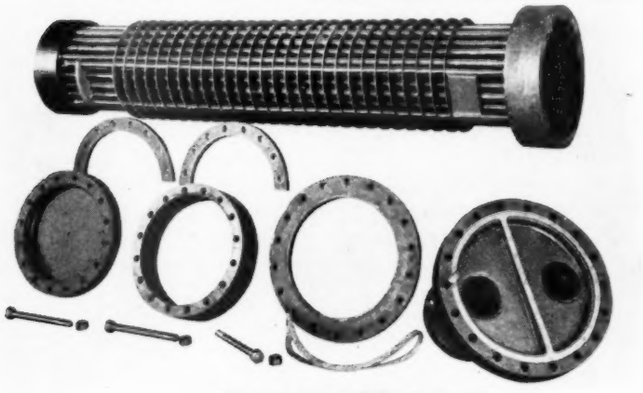

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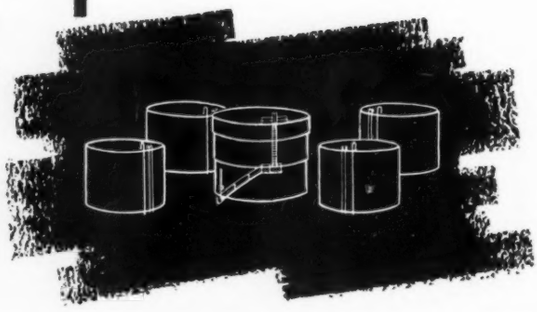

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A Practical Discussion of the Mechanics of Oil Absorption

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☆ **Bubble caps are satisfactory when gas velocities are less than 50 to 60 ft. per minute — For higher velocities perforated plates are recommended**

by J. A. Campbell
Natural Gas Engineer

J. A. CAMPBELL

entered employ of Union Oil Company in 1917 —Occupied at various times the positions of research engineer, construction engineer, superintendent of construction, design engineer, and engineer of gas plants—In 1923 accepted the position of chief engineer of the Lomita Gasoline Company, Long Beach, California, acquiring an interest in the company—In 1924 formed the J. A. Campbell Company and engaged in the design and construction of absorption plants for the next eight years—In 1932 retired from the contracting business to enter field of research and development—At the present time, he is vice-president and chief engineer of the Lomita Gasoline Company, president of J. A. Campbell Company, manufacturing and development engineers, engages in natural gas consulting work, and is an officer or director in five other companies engaged in various activities in southern California—Is a graduate of Ogden College and Yale University.

In this article the author has gone to considerable length to explain the mechanical construction of the various types of absorbers that have been used in the industry and has explained the advantages of making the oil create its own surface as it does in the various types of multistage absorbers. The balancing of the pressure drop across the plates, by the equalizing columns of oil within the tubes, is not generally understood by operators and absorption plant men. This explanation gives them a definite idea of what occurs when an absorber is overloaded.—THE EDITOR.

BEFORE beginning a discussion of the mechanics of absorption, it might be well to give a short review of the early methods of natural gasoline extraction, so as to better understand the advantages of the modern multistage absorber.

The first natural gasoline was extracted from natural gas taken from the casing of a well and inasmuch as the connection came from the head of the casing, the liquid product became known as casinghead gasoline. In later years tubing gas and tank vapors were processed to give up their liquefiable hydrocarbon content so that the term natural gasoline was adopted for the products obtained by isolating and liquefying these vapors.

The first natural gasoline was obtained by merely cooling rich natural gas—passing it through a coil in a water tank. Of course, the higher the pressure on the gas, the greater the yield of condensate obtained and it was an obvious development when compressors were installed and cooling towers built to cool the gas under pressure. The lower the temperature, the more complete the condensation of the liquefiable fractions in the gas and it was not long until the high-pressure gas, after cooling, was passed through mechancal expanders and made to do work, thereby giving up its heat. The cold expanded gas was then passed counterflow to the high-pressure wet gas after it had received preliminary atmospheric water cooling. This low-temperature high-pressure condition was quite conducive to precipitation of the gasoline vapors. The discharge from this interchanger, however, was usually into the side of a simple high-pressure tank accumulator depending on gravity for separation. A considerable amount of the condensed gasoline carried-over with the supposedly dry gas in mist form. If in those days the highly efficient forms of modern mist extractors had been available, undoubtedly the absorption method of extraction would not so soon have supplanted the compression-refrigeration method.

More than 25 years ago it was found that when wet natural gas was brought in contact with cold oil, the oil would absorb a certain percentage of the gasoline content. In absorption, the factors of temperature and pressure work in the same direction as in compression-refrigeration, although much more effectively. In those days, such excellent tools as Dalton's, Raoult's, and Henry's laws had not been adapted to the oil industry and much of our work was by rule of thumb and "cut and try" methods. It is one of the interesting sidelights on this type of development work that some of the early experimenters who never even heard of the worthy gentlemen who had expounded these basic relationships, had evolved an approximation of their laws through practical application of experimental procedure and had a fairly comprehensive working knowledge of their effects.

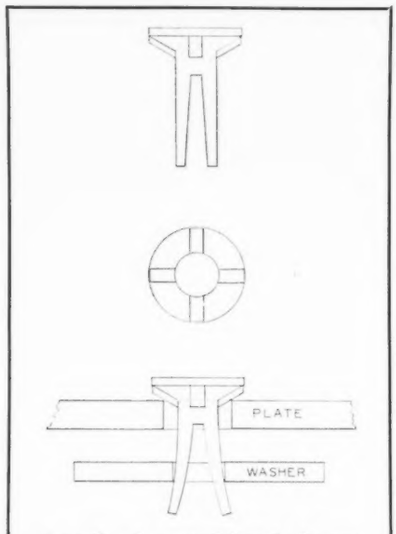
The mechanics involved in the operation of the early absorbers was rather simple as they consisted merely of tanks of oil through which the gas bubbled from holes in distributor pipes. Wire screens and baffles were next employed to slow-up and increase the time required for the passage of the gas through the oil. These devices had the additional advantage of breaking the bubbles and causing them to re-form with a new enveloping film of oil.

By this time, it had been rather firmly established that absorption was obtained through surface contact and soon very tall absorbers appeared (absorption towers they were called) containing a large quantity of material presenting an enormous amount of surface over which the oil could film. This extraneous material assumed various forms. The shells were from 1 to 3 ft. in diameter and varied in height from 30 to more than 100 ft. The material for creating oil film surface was usually in the form of cylindrical baffles. One form widely used consisted of thin wooden slats spaced about ½ in. apart. Another was made-up by

spirally rolling sheets of metal having vertical corrugations. Contiguous layers spaced by the corrugations were only ¼ in. apart. Other fillers were made of wire screen. Expanded metal lath was used. A ring-shaped tile filler was also used of such design that it presented a surface that was large relative to its volume. Towers were even filled with graded crushed rock—on modernizing one plant the writer salvaged enough crushed rock from two absorbers and one evaporator to cover the plant yard completely. The cold oil was pumped in near the top of the shell and the gas came in beneath a supporting spider or grill near the bottom. The flow, of course, was in opposite directions and the theory was that the oil would film out over the baffle material and the gas in passing the large surface thus created would give up its gasoline content to the ever-changing film of downflowing oil. The dry gas would leave the top of the absorber and the oil carrying a certain content of gasoline would go out the bottom of the shell through piping provided for that purpose.

In practice it did not work out so well. The oil was supposed to descend through the same spaces through which the gas was passing upward. Channeling was inevitable as each of the fluids will tend to take the path of least resistance and the result is that the gas will attempt to establish a path through channels free from oil, forcing the oil to follow other paths. Even assuming that distribution of the oil over the baffling is perfect, it is possible for certain molecules of gasoline to pass upward through the spaces between films without coming into contact with the surface of the oil and to emerge from the absorber with the outlet gas. To minimize the possibility of this channeling, the baffle "nests," as they were called, were staggered and collectors and redistributors for the oil were built into the assembly. Even with all these refinements the element of chance entered too much into the performance of this type of absorber. The foreign material inserted for filming the oil occupied considerable space and greatly reduced the free area besides permitting the gas to contact only one side of the film.

The next logical development came in dividing the vertical dimension of the absorber into a series of sections by installing a number of horizontal plates. Conductors were built into these plates to carry the oil from one plate to the next below. The pipes were extended above the plate surface so that in effect each plate constituted a comparatively shallow pool. Means were provided for passing the gas through the plates in such manner as to prevent the oil from passing downward through these gas passages. It was desirable to obtain a good distribution of the gas over the full cross-sectional area of the absorber so that it bubbled through all the oil in each pool successively, forming a mass of froth. Each gas bubble is surrounded by a film of oil and adjoining bubbles have a common film between them. If the gas jets or openings through the plate are small and close enough together so that the rising streams of bubbles interfere with each other, bubbles may be broken and reformed several times before reaching the surface of any one pool. The finer the bubbles in the froth, the less opportunity there is for a molecule of vapor to "hide" in the interior of a bubble and not come in contact with the enveloping film. Also the more violent the action (to a certain point) the more the bubbles are disturbed and broken and the greater is the assurance



Details of conical-headed rivet

that no gasoline vapor can "sneak" out the top without, at some point, coming in contact with a film of oil.

Various designs of plates are used for this purpose. A bubble-cap plate will have a number of chimneys or tubes open on both ends and fastened to the plates at their bottoms and extending upward to about the level at which it is desired to carry the liquid on the plate. The caps are placed surmounting these chimneys with proper clearance for the passage of the gas and so that their lower edges are below the tops of the chimneys. The gas then comes up through the chimneys, is deflected downward by the caps and passes out underneath the edges of the caps. This arrangement forms a seal or pressure lock through which the oil cannot break so it builds up to the level of the overflow and passes downward through the oil tube or tubes to the next plate where it is sealed-off below the oil level.

The perforated plate design consists of a steel plate with closely spaced perforations that give a good distribution of gas through the oil and also provide a longer path as the bubbles form at the very bottom of the pool and traverse its full depth. A better and more equitable distribution of the gas is obtained as none of the free area of the shell is occupied by chimneys or bubble-caps. There is, however, no oil seal in this type as in the bubble-cap type, and if the gas velocity through the absorber is low, the velocity through the orifices is so low that the head of oil on the plate may cause the oil to overcome the velocity head of the gas and break through the perforations. The smaller the holes the less likely is this to happen because of the greater velocity of the gas through the orifices and because of the bridging action of the film across the small gap.

There is one absorber design being used in modern plants embodying a plate having relatively large perforations into each of which is inserted a rivet with a conical head. As raised elements of each conical head there are four narrow ribs only $\frac{1}{32}$ in. high, leaving four slots $\frac{1}{32}$ in. by ¼ in. for the gas to pass through. Because of the narrowness of these slots the surface tension of the oil is great enough to bridge them over and even though the gas is shut entirely off from the absorber, the oil will remain at the level of the overflows in each pool.

In all these types, the oil passes from one pool to the one next below through the oil conductors. Some designs have only one tube and some as many as 12 per plate. Some use large tubes and some smaller tubes with collector pans on top to break-up the froth and concentrate the oil. Flow is always from a higher pressure to a lower pressure. One might ask then how it is that oil flows from one pool to the next below against a higher pressure. It is accomplished by flowing through the pressure seals. The normal pressure drop through a fully loaded modern 16-plate absorber is about 2.4 lb. or 0.15 lb. per plate. This drop is caused by the resistance offered by the gas passages and by the static head of oil on the plates. Gas pressure, we have learned, is uniform in all directions. Consequently, if we have a pressure of 30 lb. per sq. in. on the bottom plate and only 29.85 lb. per sq. in. on the plate next above, and as the overflow tubes between the two plates are open, the 30-lb. pressure on the surface of the oil on No. 1 plate will force the oil up the tubes until the 29.85 lb. per

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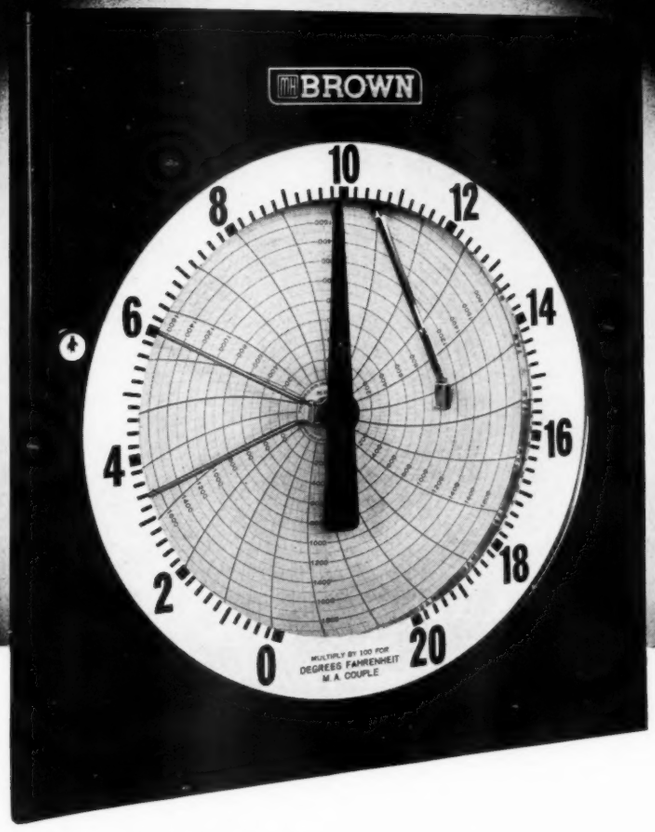

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To Measure and Control is to Economize

Type of absorber designed by the author

sq. in. plus the unit weight of the column of oil in the tube above the No. 1 level equals 30 lb. per sq. in. Suppose we are using a 38° A.P.I. oil. It would have a specific gravity of 0.835. Now 0.15 lb. greater unit pressure on the outside of a tube than on the inside would force water 0.15 times 27.7 equals 4.16 in. up the tube. But the material with which we are dealing is oil that is only 0.835 as heavy as water so it will take a higher column of oil to balance the same difference in pressure. Dividing 4.15 by 0.835 we get approximately 5 in. This would mean with no flow of oil the level in the tubes would be 5 in. higher than the level outside the tubes. But it takes additional static head in the tubes to produce flow and the greater the volume through the tubes the more additional head required. Also in actual practice, we do not get complete separation of the gas from the oil so that the oil flowing through the tubes is more or less froth and it requires a higher column of this oil to balance the 0.15 lb. per sq. in. differential pressure between plates than it would require if the oil were entirely free of entrained gas. The oil, of course, is flowing down the tubes all the time through these higher levels maintained in the tubes. These levels will remain fairly constant under constant conditions but will rise with an increase in either the oil or gas flow. When this "equalizing column" of oil within the tubes takes up all the available length of tube, the absorber is on the verge of disgorging its content of oil.

Many of the early designers of plate absorbers used a spacing of 14 in. Later they went to 16 and 18 in. and some have used as great a spacing as 24 in. When the short spacing is used, not only is there danger of the oil carrying over on gas surges, but there is a loss in efficiency from another cause. All the gas bubbles burst when leaving the surface of the froth bed. This rupture of the surrounding film throws globules of oil in all directions in the form of a mist. This mist, provided the headroom between the froth bed and the next plate is not sufficient to permit it to settle, will be carried up through the gas ports into the next pool above, which is in a different stage of absorption equilibrium.

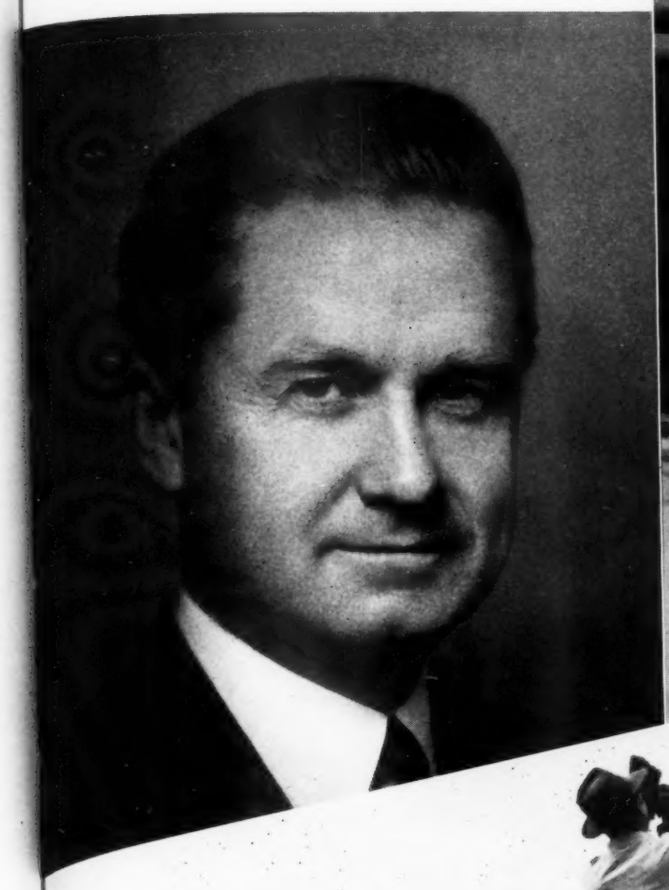
There are certain advantages and disadvantages in different types of absorbers because of their mechanical construction. A bubble-cap plate offers little resistance to the flow of gas because of the generous dimensions of the gas ports. For this reason it is important that all the plates be very carefully leveled. If not there will be less depth of oil on the high side and the gas will tend to channel through that side. Once this action is started the low side will fill with a greater depth of undisturbed oil, which will offer much more resistance to the passage of the gas than the lesser depth of frothed-up oil through which the gas is passing. Also, as bubble-cap towers usually have a very large orifice area, there is a tendency to overload them beyond the breaking point in extraction efficiency, which occurs somewhere between 50 and 60 ft. a minute expressed as free area velocity.

A properly designed perforated plate absorber will show approximately a 1-lb. pressure drop with no oil on the plates. For this reason when operated at approximate rating, the plates may be very badly out of level without affecting the gas distribution to any great extent. With reduced load, however, a perforated plate will drop its oil. Of course, if the perforations are sufficiently small this is overcome. In the early days of absorber development, small perforations were frowned upon and logically so, as we did not have available the highly efficient scrubbers now used to keep out sand and crude oil, and absorption-oil cleaning plants were unheard of. Today every well-operated plant embodies some method of cleaning the oil and gauge glasses show a light straw color instead of black as in the early plants, which was due to crude contamination.

One advantage over the bubble-cap type presented by the perforated plate is its ability to be cleaned by merely shutting-off the gas, releasing the pressure below the bottom plate, thus permitting the oil to wash any sediment on the plates through the gas orifices. This is impossible in a bubble-cap design because of the gas seals and any foreign matter that gets into the absorber must continue to accumulate.

The rivet plate contains this valuable feature and because of its small jets will not "weep" even at the lowest rates. Because it has four times as many jets per plate, the gas distribution is much more perfect and its differential pressure is no greater. As the rivets seat in quite large holes and move around freely without lifting, the plates are self-cleaning and show no tendency toward clogging-up.

Great progress has been made in the mechanics of absorption in the last 25 years and still the engineers are carrying on with their research and development work because the natural gasoline industry is, like most other industries, rapidly changing and finding new uses for its product.

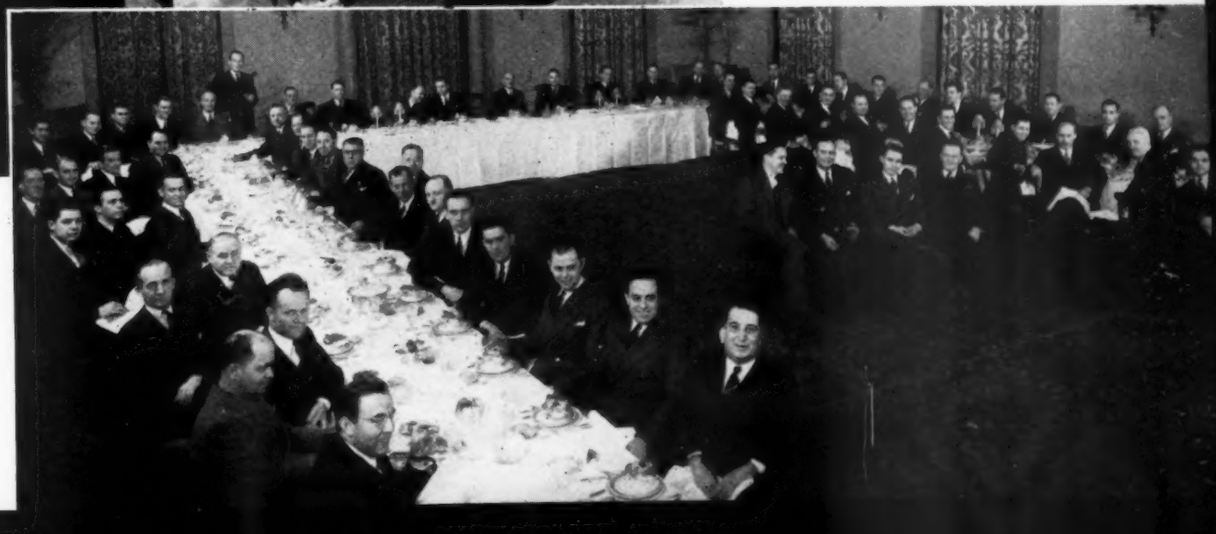


ABOVE—P. C. Jones, President, The S. M. Jones Company (seated), Mr. and Mrs. Robert W. Byrnes of Dallas, Texas, (standing), and L. J. Pundt's children, L. J., Jr. (standing), Margie Clare (left arm of chair), Gloria Ann (right arm of chair), and John Owen (on Jones' lap). Pundt is general sales manager of The S. M. Jones Company.

UPPER LEFT—Waldo Stephens, Ray B. Stephens Company, Oklahoma City, oil producers, who made the principal talk before the New York Chapter of Nomads last month.

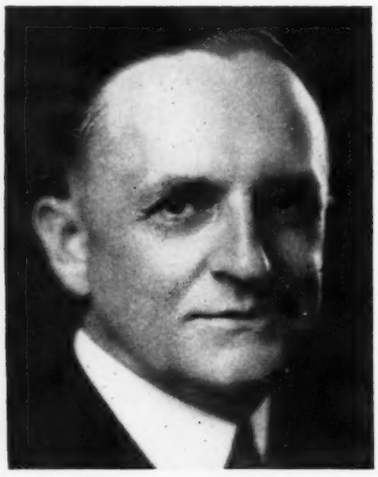
LEFT—Cole Committee witnessing bottom-hole pressure test in Magnolia field, Arkansas.

BELOW—Group picture taken at meeting of New York Chapter of Nomads. Attendance was largest in history of that chapter, 68 being present.



American Petroleum Institute Mid-Year

AXTELL J. BYLES, *President American Petroleum Institute*



W. R. BOYD, JR., *Executive Vice-President, American Petroleum Institute*

LACEY WALKER, *Secretary and Assistant Treasurer, American Petroleum Institute*

C. A. YOUNG, *Secretary, Division of Production, American Petroleum Institute*

R. P. ANDERSON, *Secretary, Division of Refining, American Petroleum Institute*

WILLIAM M. HOLADAY, *Socony-Vacuum Oil Company, Inc., will speak on "1940 Road Detonation Tests—Compiled From Report of CFR Committee"*

D. P. BARNARD, IV, *Standard Oil Company (Indiana), will give paper "A.P.I. Motor-Fuel Research"*

KENNETH E. HILL, *University of California, will deliver paper on "Factors Affecting the Uses of Gravel in Oil Wells"*

L. A. MEKLER, *Universal Oil Products Company, collaborates with H. A. Becker on paper "Air Preheaters for Petroleum Heaters"*

Meeting . . . Tulsa, Oklahoma, May 19-23

VALENTINE MEKLER, *The Lummus Company, collaborates with Wheaton W. Kraft and Ralph H. Riemenschneider on paper "Generation of Steam as a Factor in Modern Refinery Heat Economy"*

WHEATON W. KRAFT, *The Lummus Company, who collaborates on paper entitled "Generation of Steam as a Factor in Modern Refinery Heat Economy"*

PAYNE RATNER, *Governor of Kansas, will be a guest speaker at the General Session Luncheon*

RALPH H. RIEMENSCHNEIDER, *The Lummus Company, collaborates with Wheaton W. Kraft and Valentine Mekler on paper "Generation of Steam as a Factor in Modern Refinery Heat Economy"*

JOHN C. YOUNG, *of the Office of Oil Administrator, Conservation Committee of California Oil Producers, collaborates on paper "The Use of Depth-Pressure Data in Determination of Well Potentials in California"*

WALTER G. AINSLEY, *Sinclair Refining Company, will have as his subject "Evaluation of Diesel Fuels in Full-Scale Engines—Report of CFR Committee"*

L. J. KLINKENBERG, *Shell Development Company, will talk on "The Permeability of Porous Media to Liquids and Gases"*

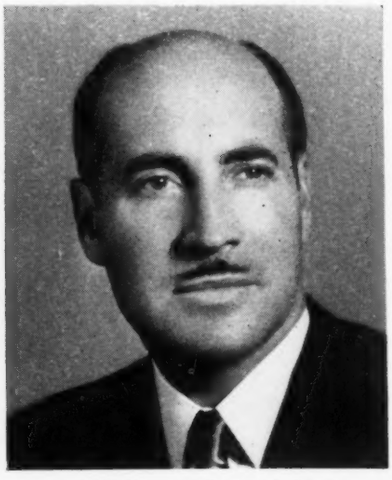
JAMES T. KEMP, *American Brass Company, speaks on "Corrosion of Copper-Alloy Condenser Tubes by Water"*

B. B. MORTON, *The International Nickel Company, has as his subject for a paper "Water-Side Corrosion of Condensing Equipment"*

Western Metal Congress Meets in Los Angeles
(MAY 19 - 23)

A. G. ZIMA, *Western Representative, International Nickel Company, General Chairman*

B. H. BROWN, *Metallurgist, Bethlehem Steel Company, Vice-Chairman*



P. D. McELFISH, *Standard Oil Company of California, Chairman, Co-operating Committee of Technical Societies*

HAROLD ETTER, *District Manager, Air Reduction Sales Company, Entertainment Chairman*

J. E. WILSON, *Metallurgist, Climax Molybdenum Company, Information and Registration Chairman*

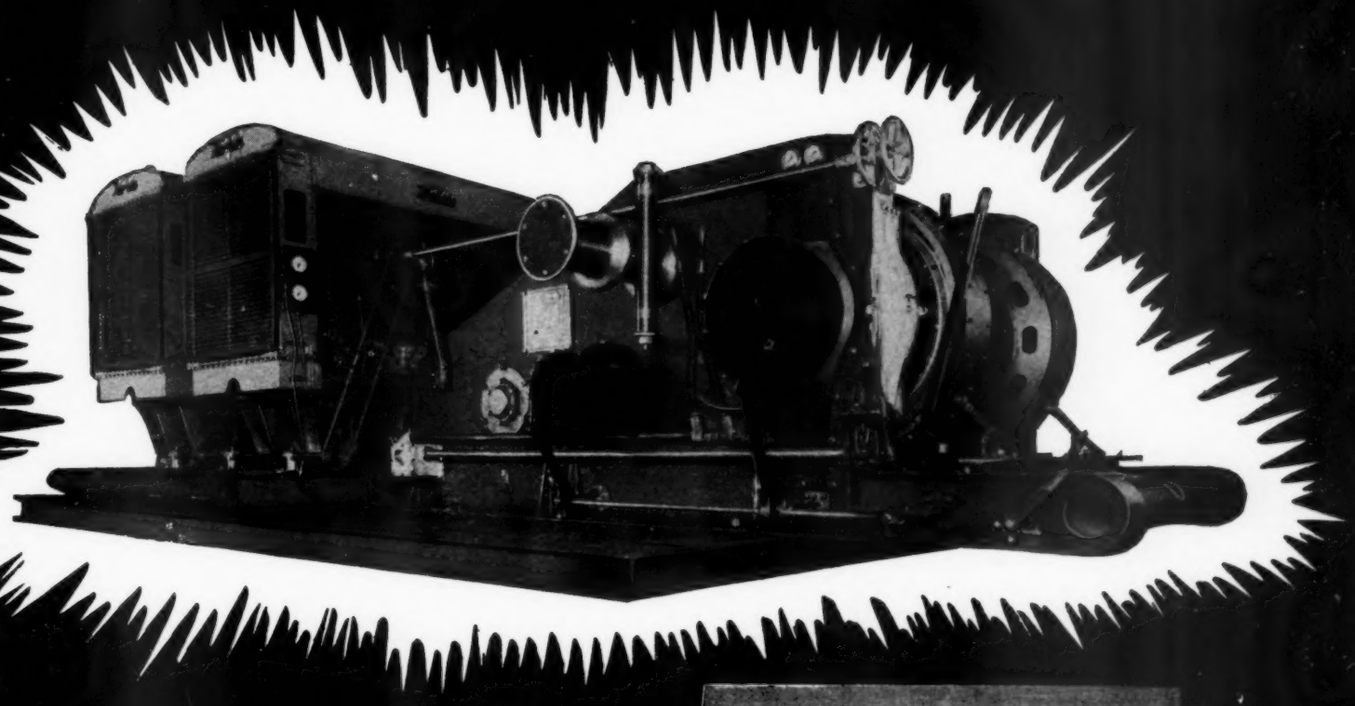
H. J. FRENCH, *International Nickel Company, will deliver four talks on alloy steels*

W. A. DeRIDDER, *President, General Metals Corporation, Publicity Chairman*

A. W. WINSTON, *Metallurgist, Dow Chemical Company, will give two talks on magnesium alloys*

H. W. McQUAID, *Assistant Chief Metallurgist, Republic Steel Corporation, will deliver two talks, one on carbon steels and one on petroleum field metals*

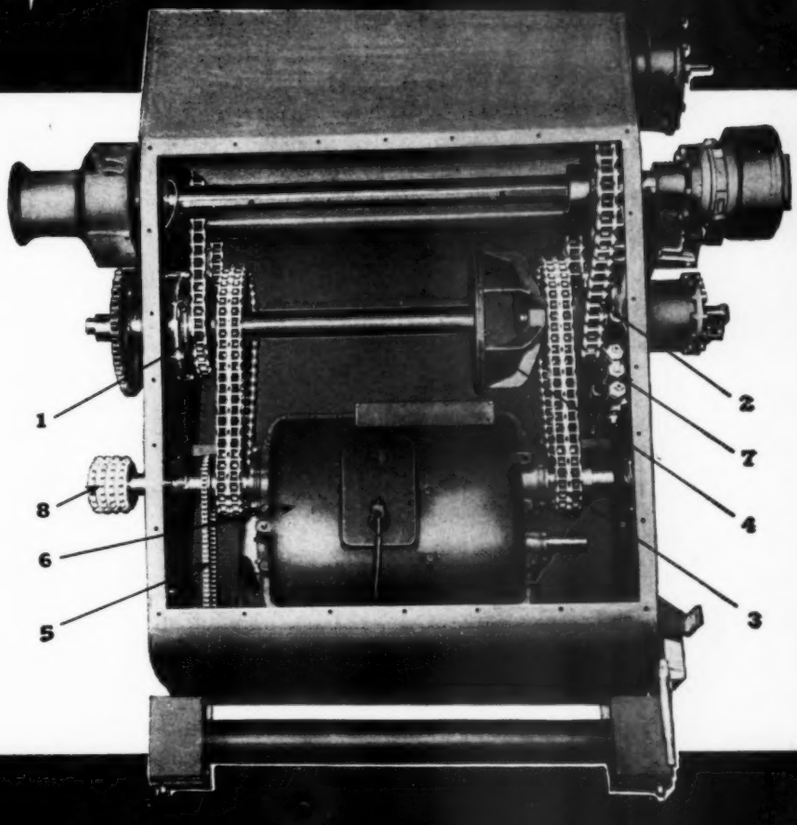
HYDRAULIC CONTROLS

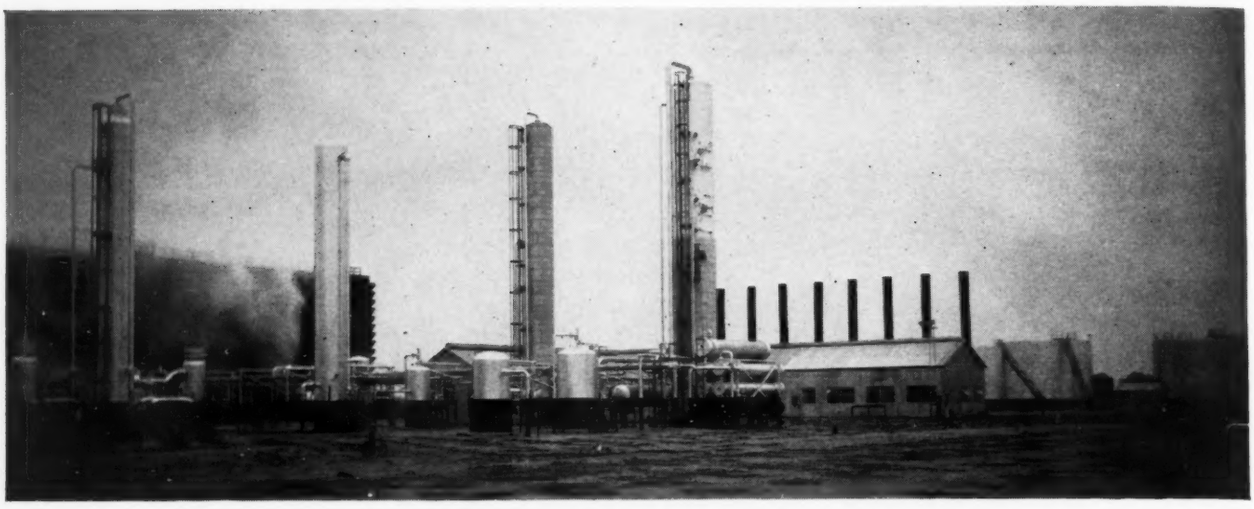


Hydraulic pressure insures safe, positive control of drum and rotary clutches. Safe operation and accuracy is obtained by a simple, balanced valve operated by foot pedal at driller's position, fluid supplied from lubricating source. Foot pedal pressure remains constant whether driller is using maximum or minimum amount of available horsepower. Clutches are cone type, have full pressure engagement and release and require no adjustment; are not affected by expansion or contraction.

The photograph at right shows the interior of the Model CT-5 Draw Works: (1) High speed drum drive independent of transmission; (2) Low speed drum drive, giving 4 forward and 3 reverse speeds to drum; (3) Drive to rotary shaft, providing 4 forward and 3 reverse speeds to rotary table; (4) Cone friction rotary clutch; (5) Oil pump drive independent of transmission speeds; (6) Heavy duty herringbone transmission; (7) Pressure regulator assembly for lubrication system; (8) Transmission input sprocket, quadruple width.

A complete description of this and other Portable Rigs is carried in the 1941 Composite Catalog, or write for descriptive literature.





General view of Shamrock - Lone Star Cycling Plant at Opelika, Texas

Dual Pressure Systems Serve First Cycling Plant Installed in Opelika Area

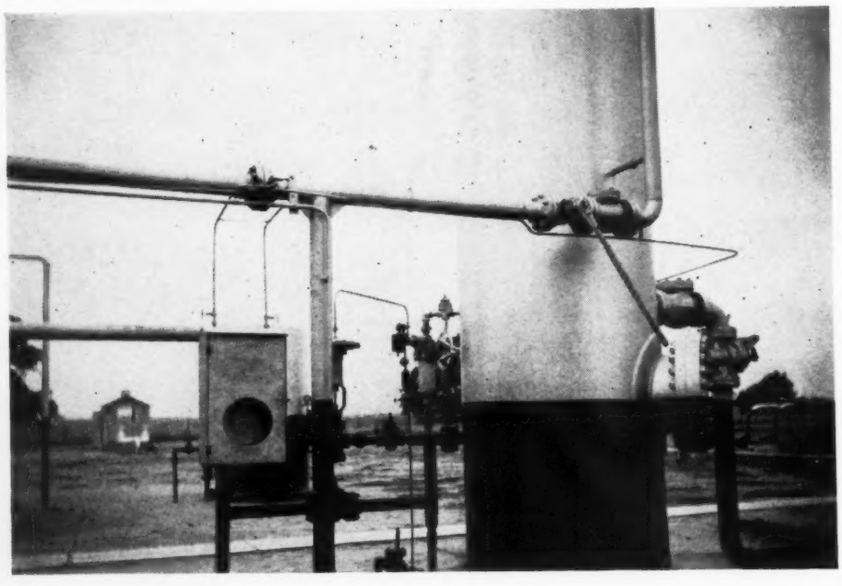
PETROLEUM ENGINEER Exclusive Feature

☆ **Recently completed plant has 80,000,000 cu. ft. daily capacity—four 600-hp. compressors are designed for a maximum working pressure of 6000 lb.**

by Frank H. Love
Managing Editor

THE first cycling plant for the Opelika area, Henderson County, Texas, has been constructed jointly by the Shamrock Oil and Gas Corporation and the Lone Star Gasoline Company. This plant, having a total capacity of 80,000,000 cu. ft. of gas per day, has been in operation several weeks and just recently a high-pressure absorber was added to the original equipment and placed on stream.

Low-pressure absorber showing metering and control equipment



Design of the plant provides for the handling of the gas through two systems: a high-pressure and a low-pressure system. The capacity of the former is 60,000,000 cu. ft. of gas per day, and of the latter, 20,000,000 cu. ft. Residue gas from the low-pressure system is marketed commercially; gas from the high-pressure system is used to repressure the producing formation in the field.

Gas received at the plant enters a common header. Gas to the low-pressure system is passed through a steam jacket and heated to offset hydrate formation, then enters the low-pressure absorber. At the absorber the pressure is reduced by an adjustable choke from 2500 lb. per sq. in. (the plant inlet pressure) to about 400 lb. The temperature on the absorber is maintained slightly above 70°F. From the absorber the gas is discharged into a 12-in. line of the Lone Star Gas Company and delivered to the Texas Power and Light Company's plant at Trinidad, Texas, where it is used as fuel.

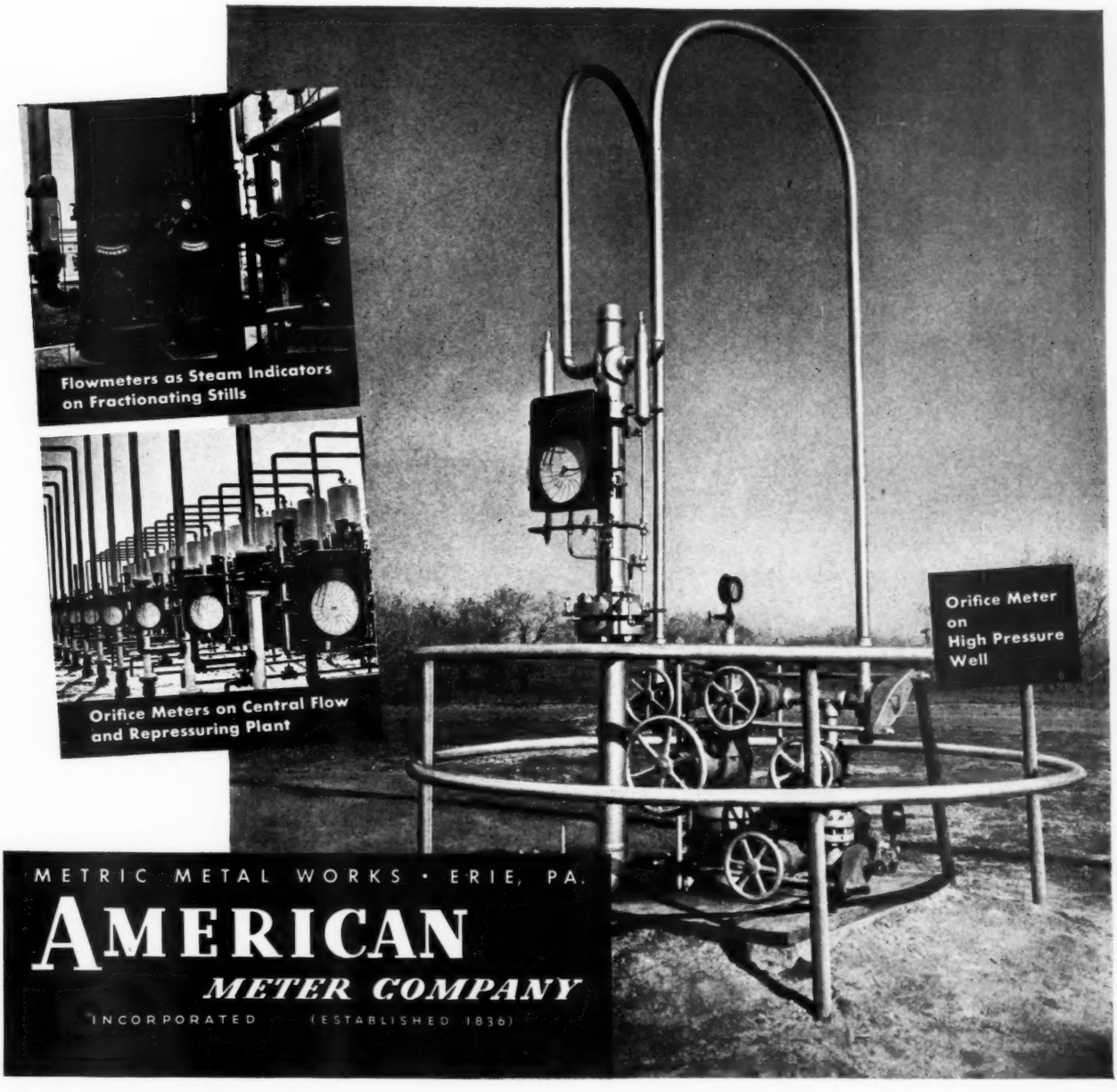
Gas to the high-pressure system

The key *to successful* repressuring

The modern way of oil and gas men is to drag even the "squeal" out of producer and reserve wells! And it works — when plant and field conditions and equipment conform strictly to the right engineering set-up.

Talk with the engineers and maintenance men. Learn why METRIC-AMERICAN Orifice Meters and Flow-meters are specified for so many of these ticklish jobs—where to be inaccurate or slipshod or fragile may put a dent in profits!

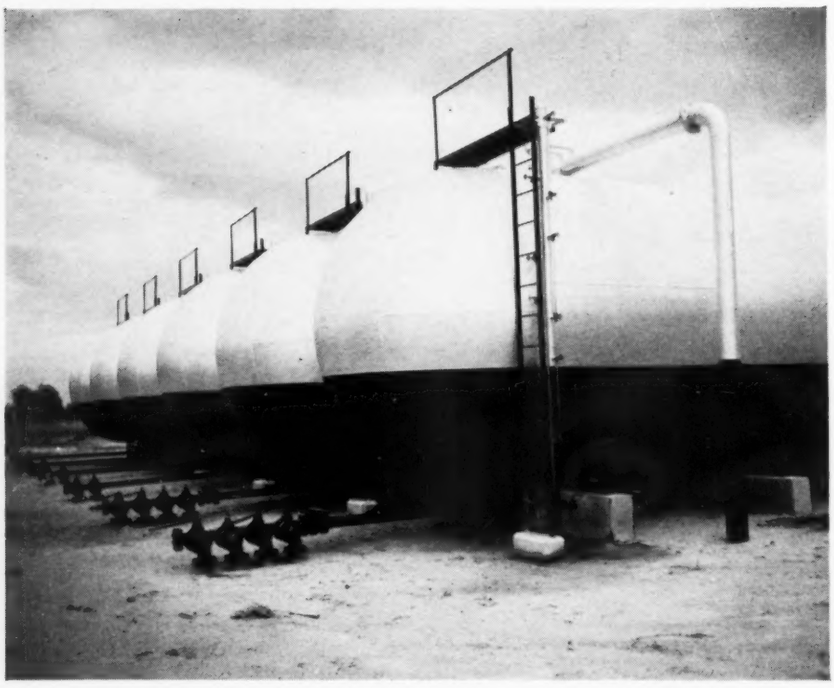
NOTE: Construction and design features of these dependable instruments are detailed in American Meter Company's engineering bulletins which will be mailed you upon request.


Flowmeters as Steam Indicators on Fractionating Stills
Orifice Meters on Central Flow and Repressuring Plant
Orifice Meter on High Pressure Well

METRIC METAL WORKS • ERIE, PA.

AMERICAN METER COMPANY

INCORPORATED (ESTABLISHED 1836)



Horizontal hemispherical-head tanks for product storage

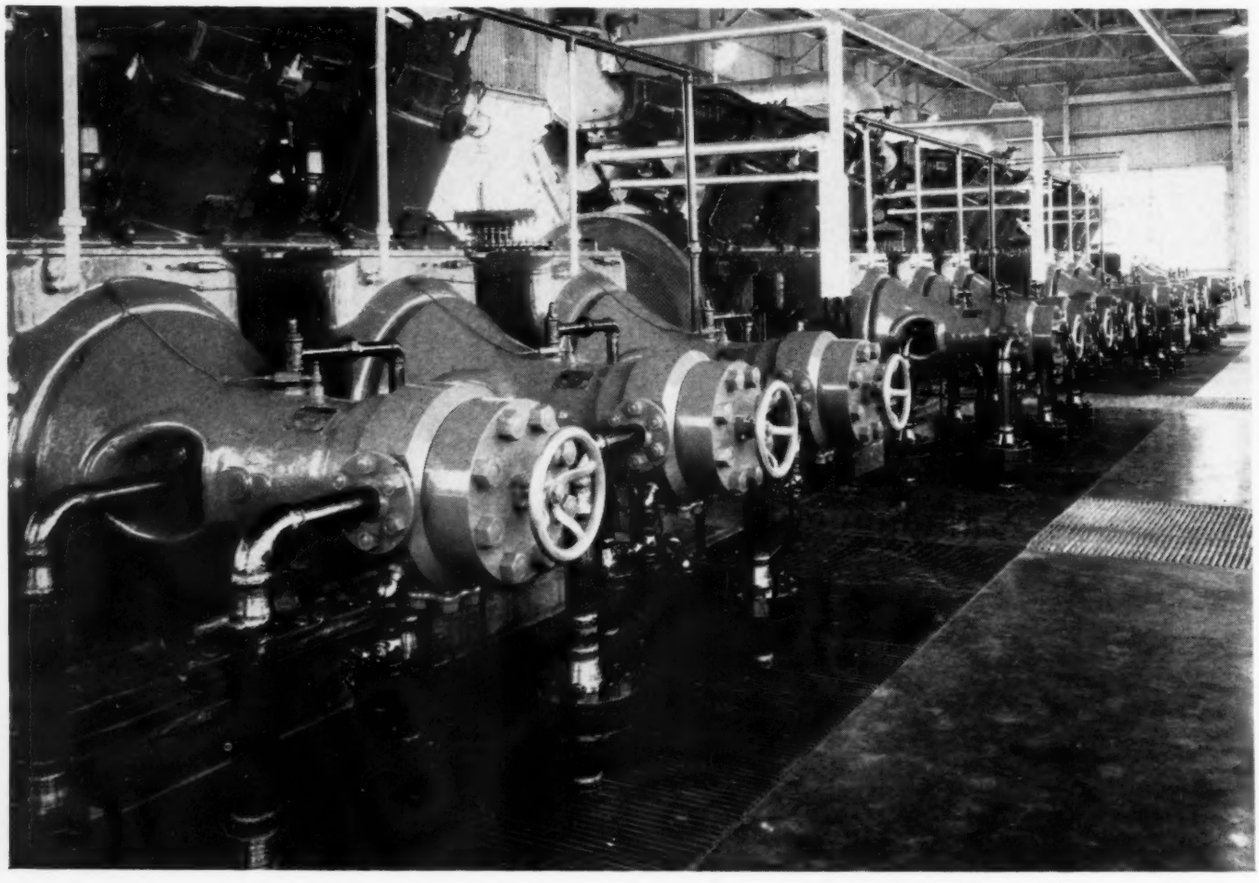
comes off the header at a temperature of 140°F. and passes through two gas coolers, the temperature being reduced to 110°F. On its passage from the coolers to a high-pressure separator the gas pressure is reduced from 2500 lb. to 1750 lb. by a regulator, after which it is discharged to the high-pressure absorber. The absorber, which is 53 in. in diameter and 43 ft. 1½ in. high, is designed to operate at a maximum working pressure of 2200 lb. After leaving the high-pressure absorber the flow is through a scrubber into the suction of the compressors. The gas enters the compressors at a pressure of 1750 lb. and a temperature of 84-85° F.; discharge is at a pressure of 4050 lb.

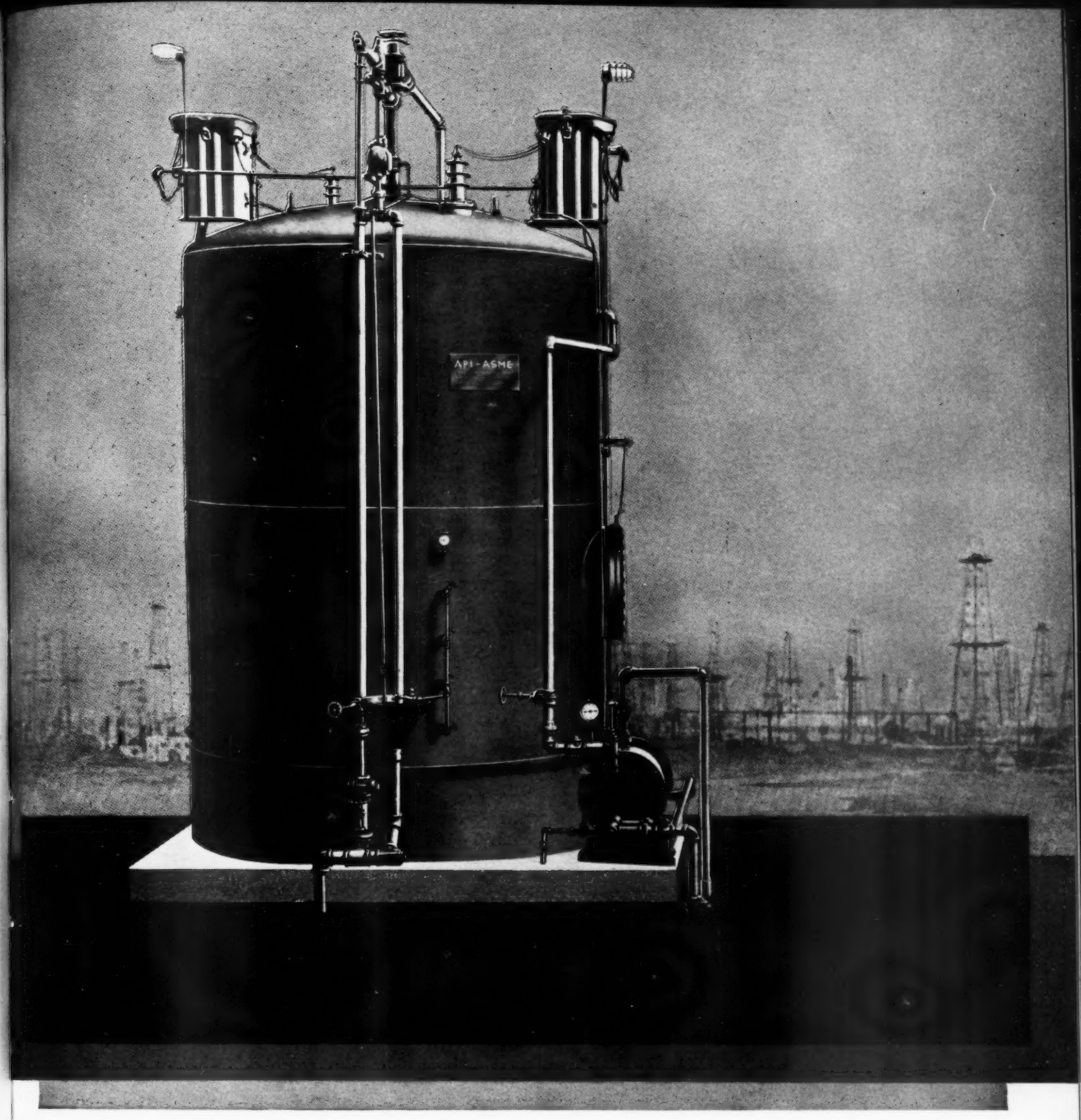
Details of Compressors

Four 600-hp., V-angle compressors, with compressor cylinders designed for a maximum working pressure of 6000 lb. compress the gas and discharge it to the injection well. Each unit has six 14 by 14 power cylinders and three 3⅞ by 14 single-acting, piston-suction-type forged-steel compressor cylinders.

Power pistons are oil-cooled by a continuous flow of oil through an enclosed chamber beneath the piston crown. The fuel gas manifold is situated between the two banks of power cylinders and connects with each cylinder head. A gas injection valve, placed at the entrance to the gas manifold, is governor-controlled and varies the

The four 600-hp. V-angle compressors have a maximum working pressure of 6000 lb.





With our nation definitely engaged in a program of defense, conservation of petroleum and its products becomes not merely important, but vitally imperative.

Petreco Electromatic Dehydration long has been recognized as a valuable aid in petroleum conservation. It recovers all the oil from the emulsion; restores the crude to its true gravity; conserves the most valuable fractions of the production; cuts storage facilities and maintenance to minimum; reduces handling and transportation costs; and in various ways pays dividends all along the line from the well through the refinery.

Even when emulsified crudes test within pipe line specifications, Petreco Electromatic Dehydration may prevent important losses and provide increased revenues. Petreco's engineering and research facilities are available at all times for expert assistance in determining the most effective dehydration procedure. Call your nearest Petreco representative for further information.

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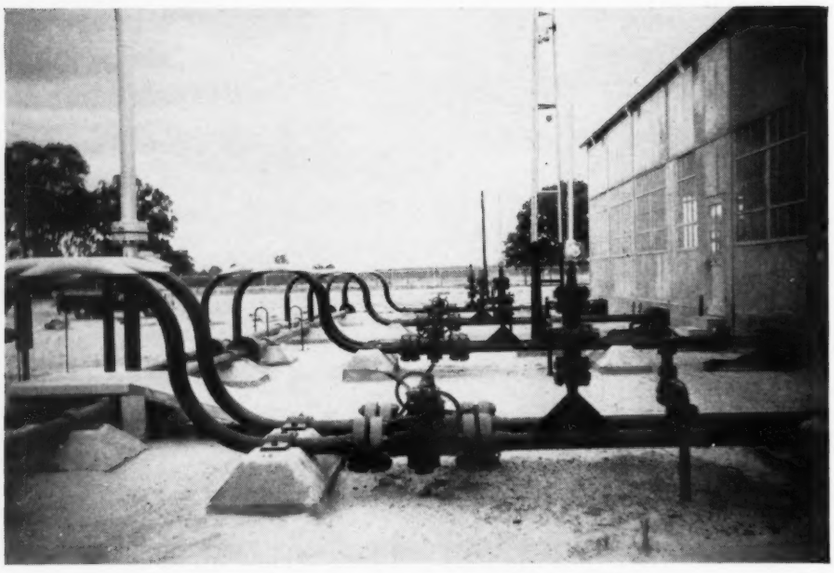
PETRECO

DEHYDRATING DE-SALTING



Suction lines to compressors

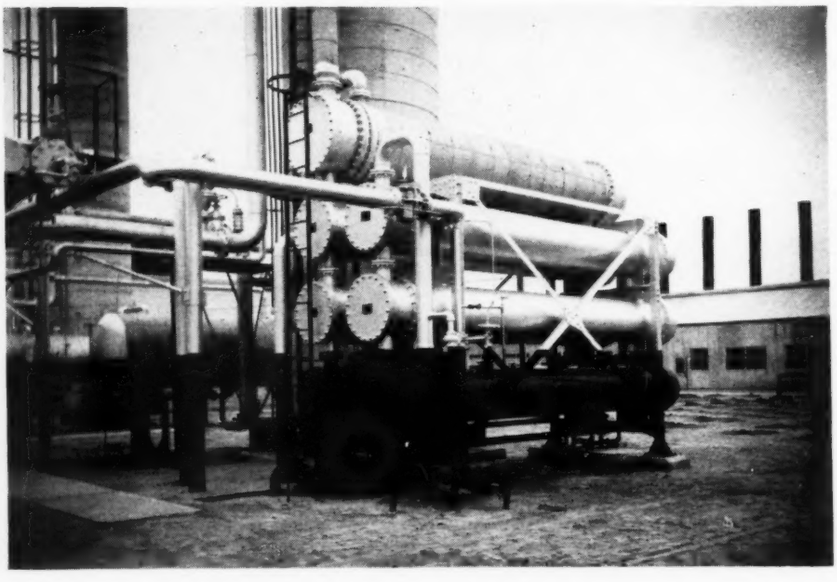
amount of fuel admitted to the manifold according to requirements necessitated by the changing load upon the engine. In the center of each cylinder head is a mechanically-operated injection valve that is actuated by a push rod operated directly by an adjustable cam on the crankshaft.

To provide lubrication to all main, crankpin, piston pin, crosshead, and auxiliary driveshaft bearings, an oil pressure pump is built into the base of the engine, being chain driven from the crankshaft. This pressure system also supplies lubrication to the governor, auxiliary drive mechanism, and all moving parts within the engine base. A pressure-regulating valve maintains a definite oil pressure at all points in the lubricating system, and when the engine is not in operation a spring-loaded check valve at the end of the system keeps the oil lines filled. Power and compressor cylinders are lubricated by two force-feed mechanical lubricators that also lubricate the compressor-rod packings.

A pressure-type oil filter is situated between the lube oil pump and the oil cooler, the lubricating oil passing through the filter before going to the cooler. From the cooler the oil passes to the distribution system and then is returned to the sump in the base of the engine.

Each compressor unit has a built-in centrifugal cooling-water pump driven by two V-belts; rate of water circulation is 25 gal. per b.hp-hr. at normal speeds. The pump discharges through the lube cooler and into the engine cooling system. Outside water-jumpers carry cooling water from the cylinder blocks to the cylinder heads. The engine inlet water header is also piped to the compressor cylinders and valves regulate the flow of cooling water to each cylinder.

Scavenging air is supplied by horizontal scavenging pistons attached to the compressor cylinder crossheads. Discharge is into a common receiver cast integral with the base of the engine. There is a scavenging piston for each crankthrow of the engine regardless of the number of compressor cylinders used. Each scavenging air port is constructed as a venturi nozzle. The size of the air ports decreases as they progress around the cylinder away from the exhaust ports, causing a uniform velocity of air to flow into the cylinder, serving also to prevent the intermingling of fresh air and exhaust gases. The scavenging air flows upward on the inlet side of the cylinder and downward on the exhaust port side.

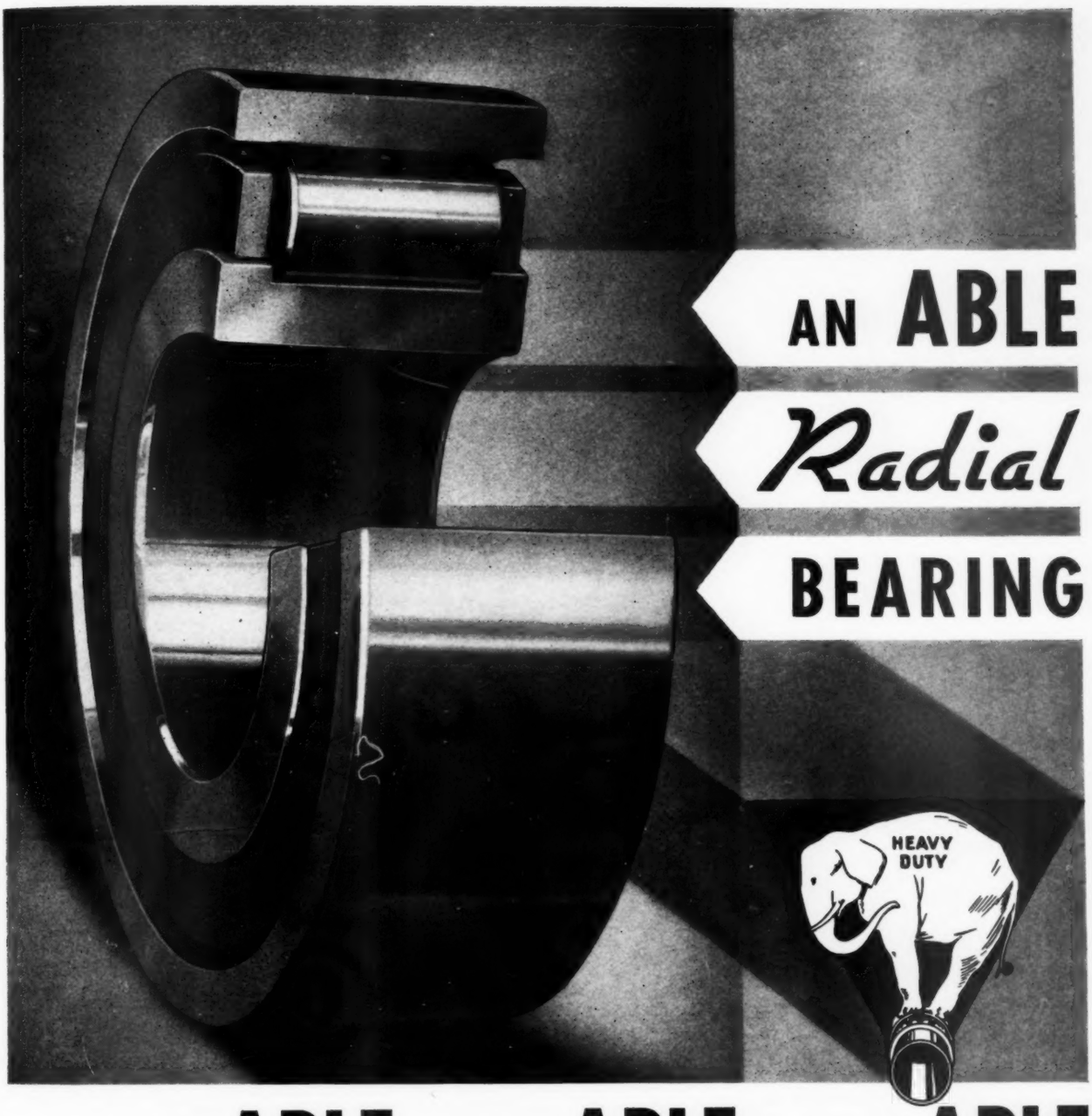


Heat exchangers on still-dephlegmator

Processing

Liquid from the high-pressure separator and high-pressure absorber is flashed into the low-pressure absorber, which is 6 ft. in diameter by 44 ft. 2 in. high. The reduction of pressure involved in this operation is from 1750 lb. to 400 lb. Rich oil and this liquid are then flashed from the low-pressure absorber to the high-pressure vent tank, upon which a pressure of 150 lb. is held. Gas coming off the vent tank is used as compressor and boiler fuel. Liquid from the high-pressure vent tank passes to the low-pressure vent tank, a pressure of 35-40 lb. being maintained on the latter. Gas from this vent tank is also used as boiler fuel. Liquid is discharged from the low-pressure vent tank through six heat exchangers and preheaters into the combination still and dephlegmator. The still-dephlegmator is 7 ft. in diameter by 61 ft. high, and is operated at a temperature of 360°F. and a pressure of 35 lb. Lean oil is taken from the still bottom and passed through atmospheric cooling coils in the base of the cooling tower, thence to a surge tank. A part of this oil is used for absorption purposes in the low-pressure absorber and the rest is sent to storage where it is mixed with the stabilized gasoline forming what is termed crude distillate.

Vapors from the still-dephlegmator are discharged through cooling coils and the condensate enters the raw make tank. Vapors from the make tank are either used as boiler fuel or vented, whereas the liquid is used for still reflux and stabilizer charge. On



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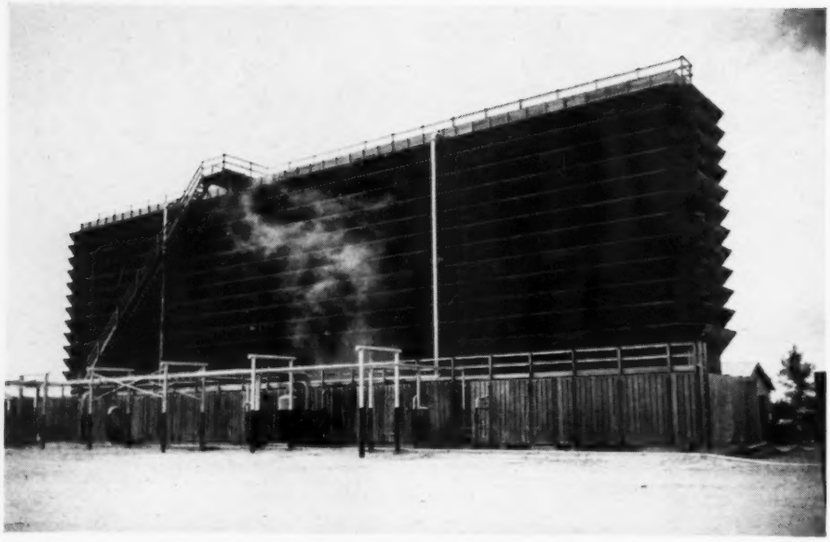


Atmospheric-type, 22-bay cooling tower

the stabilizing unit a base temperature of approximately 360°F. and a top temperature of about 150°F. are maintained. Vapors leaving the top of the stabilizer pass through condensers, the liquid entering an accumulator tank. A part of this product is refluxed over the stabilizer and the rest goes to storage. The stabilized product and the still bottoms enter a common storage to form crude distillate, as mentioned before, the product marketed by the plant. This product has a Reid vapor pressure of 5 to 5½ lb.

Miscellaneous

Product storage consists of three 5000-bbl. vertical tanks, three 10,000-bbl. vertical tanks, and six 50,000 gal. horizontal hemispherical-head tanks. From storage the product is pumped through a 38-mile, 4-in. pipe line to the Gulf Refining Company's Big Sandy station, where it enters the company's trunk system to the Gulf Coast. To pump the crude distillate through the line two pumps are provided, both of the reciprocating type. One is equipped with a 4½-in. liner and piston and has a capacity of 230 bbl. per hr. at 1000-lb. pressure. The other has a 3½-in. liner and piston, its capacity being 145 bbl. per hr. at 1000-lb. pressure. The latter pump is also used as a standby pump for high-pressure absorption oil service. When used for this purpose its capacity is 100 gal. per min. at a pressure of 2000 lb. The product is metered into the line by two positive meters and an orifice meter, the latter serving as a check on the former.

A common surge tank has been provided for the absorption oil used in the high-pressure and low-pressure systems. A plunger-type pump driven by a 150-hp. gas engine discharges absorption oil to the high-pressure absorber. The pump has a capacity of 139 gal. per min. at a pressure of 2200 lb. The 14 by 6 by 12 duplex plunger-type pumps, steam-driven, pump oil to the low-pressure absorbers.

Steam for processing and to drive the steam pumps is provided by eight 120-hp. locomotive-type boilers having a working pressure of 300 lb. per sq. in. Two insulated tanks serve as low-pressure and high-pressure hot wells. All exhaust steam from the steam-driven pumps is condensed and recovered, reducing the volume of boiler make-up water required.

Water supply is from a 551-ft. well drilled on the plant site. Water is pumped from the well by a deep-well pump driven by a steam turbine to a 2000-bbl. water storage tank and to the pit of the cooling tower.

The cooling tower is of the atmospheric type and has 22 bays. Water is circulated over the tower at the rate of 4000 gal. per min. by two centrifugal pumps driven by steam turbines. Another similar unit is being installed.

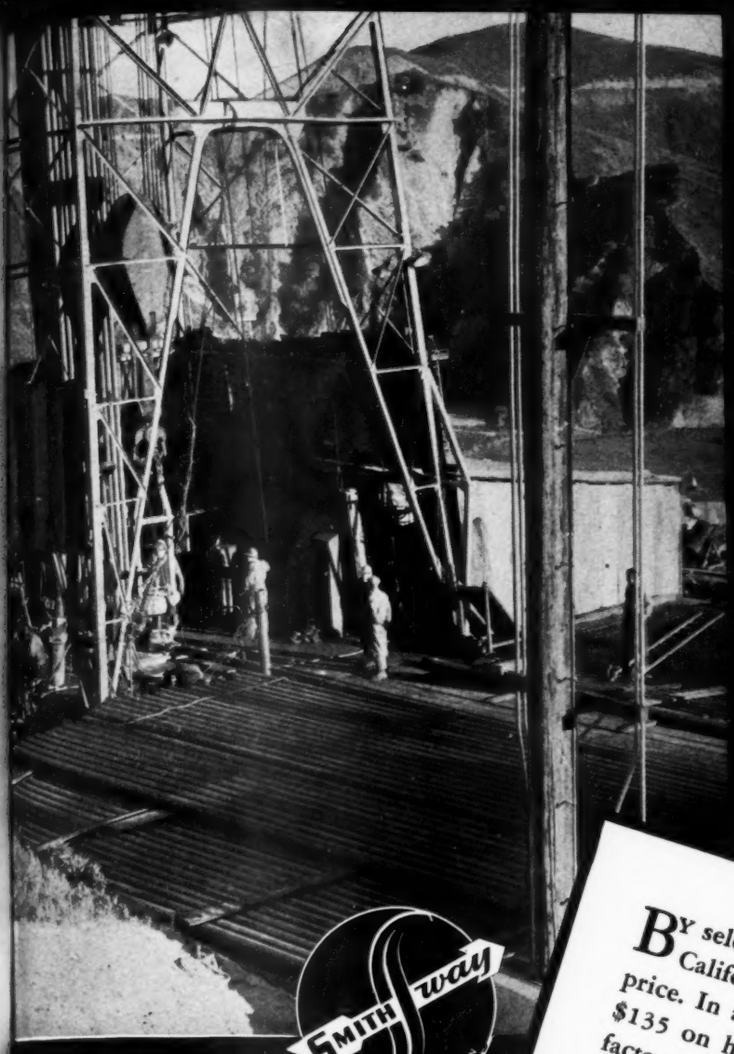
Seven producing wells are connected to the plant. Depth of the wells is 8000-8250 ft. in the Glenrose formation. Bottom-hole pressure is 3200 lb. and the wellhead pressure 2600-2800 lb. Some of the wells are being produced open through tubing and others through a choke on the casing.

Injection for repressuring is through a single key well situated just outside the fence that encloses the plant proper. Injection is through casing or tubing at a pressure of 4000 lb. per sq. in. Pressure drop in the line from the compressor to the well is 50 lb.

Gathering lines consist of two 4-in. and one 5-in. main lines plus numerous laterals varying in size from 2½ in. to 5 in.

Design and construction of the plant were by the engineering department of the Shamrock Oil and Gas Corporation. Operation of the plant is by the same company.

Injection into the key well is at a pressure of 4000 lb.



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Reconditioning Oil Wells in The Greater Seminole Area of Oklahoma

Attention is called to the various factors to be considered in planning to shoot a well, particularly the extreme horizontal displacement in old wells before controlled drilling came into vogue

(PART 1)

by J. I. Laudermilk Instructor, Petroleum Engineering, University of Texas

THE reconditioning of oil wells is an important problem of petroleum production at the present time in the Greater Seminole Area of Oklahoma, and will become of increasing importance in future years as more and more wells approach the economic limit of operation under existing conditions. The Upper Wilcox Sand is one of the most important producing formations in this area from the viewpoint of an engineer engaged in reconditioning work. This importance is due to the fact that great numbers of oil wells in this area are now producing or have possibilities of future production from this sand. One of the most important methods of reconditioning this formation is by the use of nitroglycerine explosives. An understanding of the factors affecting the shooting of the Upper Wilcox Sand in the Greater Seminole Area is essential if satisfactory results are to be obtained.

Although many arguments have been voiced in the past concerning the action of the explosion in the geologic formation and various theories have been advanced to explain the different viewpoints, complete unanimity has been reached upon the importance of considering each well by its individual characteristics and determining from these its suitability or non-suitability for shooting. It has been the writer's personal experience that this fact cannot be overemphasized, and that indiscriminate shooting is not economically justifiable and may actually result in physical harm to the well in addition to being a needless financial burden to the company. There are certain definite factors common to all wells, however, that influence this determination. Some of these factors are generally applicable to many areas; others are restricted more or less to localized regions in which they are present.

As a preliminary step to shooting, the individual well should be studied on its own merits if the necessary data are available. In general the factors affecting the shooting of the Upper Wilcox Sand in the Greater Seminole Area of Oklahoma include the items discussed below as to use and importance.

J. I. LAUDERMILK

was born November 22, 1909, at Chickasha, Oklahoma—Attended University of Oklahoma and received degrees of bachelor of arts and bachelor of science in general engineering—The professional degree of petroleum engineer is to be conferred by the University of Oklahoma in June, 1941—Employed as petroleum engineer by Gulf Oil Corporation previous to becoming a member of the faculty of the Department of Petroleum Engineering, The University of Texas.

Date of Initial Completion

Date of initial completion is of value inasmuch as this factor will materially affect the amount of oil yet to be recovered. A good producing well that has been on production a number of years may not offer the same inducement for reconditioning that exists in the case of a less prolific well that is of more recent completion and is not as likely to have exhausted its reserves to a similar extent. This information is almost without exception readily available on all oil wells.

Casing Program

Size of casing string. The size of most oil strings of casing in the Greater Seminole Area is ample to permit the use of any reasonable size torpedo shell in placing the explosive at the desired depth. In some cases this is not true, however, for the size of the shell is restricted by the casing, and thus to some degree the amount of concentration of the shot possible is limited when torpedo shells are used to place the explosive, for a minimum annular space of one-half inch is required between the shell and the casing string through which it is run. Failure to recognize the limitations placed upon the size of a torpedo shell by the oil string and neglect of proper clearance have frequently resulted in disaster, causing at best considerable additional expense for reconditioning that could have been avoided, and threatening at worst to cause complete loss of the oil well. The writer was present at the shooting of one oil well in the Greater Seminole Area where this factor was completely ignored, and the engineer in charge of the shooting ordered a shell to be run of a size that did not permit adequate clearance. At a depth below 4000 ft. the shell became lodged in the well and in attempting to recover it, the shooter's line was broken at the casing head leaving more than 4000 ft. of steel torpedo line in the hole, as well as the shell itself. Fortunately the shell had been loaded only with water and was being used as a "dummy" to explore the hole preliminary to placing the nitroglycerine, so that it was possible by use of suitable fishing tools to recover the lost material and not lose the oil well. Complete disaster could very easily have resulted, however, had experienced men not been in control of the fishing operations, or had a live torpedo shell been run. As it was, considerable expense was involved that could and should have been avoided by proper recognition of the importance of this factor and its effect upon the shooting of an oil well.

Length of casing string. The length of the casing string is of even greater importance than the size, for the explosive must be placed at a sufficient depth below the casing seat to

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prevent damage to the casing. In instances where this has not been done, the force of the explosion has damaged or ruined the oil string necessitating expensive repairs if not total loss of the well. This factor is not as important in shooting the Upper Wilcox Sand in the Greater Seminole Area of Oklahoma, however, as in many other petroleum producing regions, probably due to the fact that in most cases the size of the shot is comparatively small, seldom exceeding 50 or 60 quarts of nitroglycerine, and the distance between the casing shoe and the top of the shot is usually sufficient to permit adequate damping of the effects of the detonation of the explosive if proper sand tamping and fluid stemming are used. In no single instance covered by this investigation was the casing collapsed by shooting the Upper Wilcox Sand, and it is believed that by the exercise of reasonable precautions this danger can be eliminated when using small or medium-sized shots as has been customary in the past.

Type and grade of casing. The type and grade of casing used in the oil well has a very definite influence on the possibility of the detonation of the explosive causing damage to the casing string. It is obvious that the higher grades of casing—i.e., those grades possessing higher physical properties — should resist the effects of shooting better than the lower grades of casing and should, therefore, not be damaged so easily nor so frequently. Similarly, it has been observed that seamless steel casing successfully withstands the shock of shooting and that where this type of casing is used, shots can be placed in reasonable proximity to the casing seat.

The mechanics involved in the collapse or damage of casing due to shooting are not clearly understood, and become very involved when approached from a theoretical standpoint.

Information concerning the sizes, lengths, types, and grades of casing strings in this area is usually readily available. The relatively high cost of casing, frequently amounting to from 35 to 40 percent of the total cost of the well, was sufficiently great to cause accurate records of these data to be kept even under the conditions of an old-type oil boom such as existed in the Greater Seminole Area.

Total Well Depth

The total depth of the well is quite important for several reasons. Insufficient total depth will limit the size of shot that can be used without damaging the casing. In some instances, comparatively rare in the Greater Seminole Area, this feature will entirely eliminate the possibility of shooting the producing formation. The total depth of the well may also be used, together with the surface elevation and vertical correction, to determine the location of the shot in the formation so as to reduce the danger of shooting too close to the oil-water contact and thus causing premature water encroachment or an increase in the existing water-oil ratio of production. Another use is for geologic correlation with other wells that have been similarly reconditioned in the past.

TABLE I

Vertical corrections of typical old oil wells in the Greater Seminole Area of Oklahoma

Well no.	Location (pool)	Depth of last survey, ft.	Total vertical correction at depth of last survey, ft.
1	Earlsboro	4500	207
2	Earlsboro	4490	118
3	Seminole	3875	97
4	Seminole	3950	13
5	Seminole	4095	74
6	Earlsboro	4375	197
7	Earlsboro	4200	122
8	Seminole	4120	8
9	Seminole	4125	74
10	Seminole	4100	1
11	Little River	3700	219
12	Little River	3825	152
13	Seminole	4250	146
14	Little River	4500	490
15	Little River	3800	224
16	Little River	3750	61
17	Mission	4000	17
18	Mission	4450	450
19	Mission	4500	447
20	Mission	4500	567
21	Mission	4400	300
22	Konawa	3850	122
23	Mission	4450	450
24	Little River	3825	152
25	Little River	4500	573
26	Little River	3700	219
27	Little River	4000	31
28	Mission	3800	19
29	Bowlegs	4158	113
30	Mission	4100	7
31	Earlsboro	4000	7
32	Mission	3750	34
33	Mission	4100	16
34	Earlsboro	4250	49
35	Earlsboro	3875	2
36	Mission	4000	10
37	Mission	4000	2
38	Mission	3950	11
39	Allen	3900	8
40	Earlsboro	3800	15
41	Mission	3950	1
42	Earlsboro	4000	15
43	Earlsboro	3750	33
44	Earlsboro	4000	7
45	Earlsboro	3950	9
46	Earlsboro	3750	2
47	Earlsboro	3900	2
48	Little River	3800	152
49	Little River	4500	573
50	Bowlegs	4050	15
51	Earlsboro	3950	5
52	Earlsboro	3950	10
53	Little River	4250	253
54	Searight	4400	111
55	Earlsboro	4000	7

Oddly enough, accurate information as to the total depth of a well instead of being easily obtained often is very difficult or even impossible to get. Prior reconditioning work often results in changes in total depth that frequently are not made a part of the well record. The only certain method of obtaining this information accurately is actually to measure the depth of the well with a steel line and mechanical measuring device, various types of which are in common use at the present time. Even this is not entirely satisfactory in cases where appreciable amounts of cavings or foreign materials are in the well bore.

Surface Elevation

The importance of surface elevations in reconditioning work lies in the fact that variations in the ground surface are reflected in the depths necessary to reach a given geological marker or horizon in different wells. If an attempt is made to correlate data from various wells in a given region, these variations must be eliminated. For this reason nearly all correlations are made with respect to sea level as the datum plane.

In many cases the surface elevation of an oil well in the Greater Seminole Area can be obtained from professional surveys that have been made in the past. When this is not true, it is merely a problem of elementary surveying to run a line of levels from some known elevation to the well in question.

Vertical Correction of Depth

Vertical correction of depth is one factor that is virtually non-existent in wells drilled at the present time using modern drilling and completion practices. Only in the cases of those wells that are purposely drilled at predetermined variations from the vertical is this factor encountered, although modern methods of directional surveying of the well bore permit its location at all points to be known. In view of this fact, even technically trained production engineers not conversant with conditions existing in the old wells drilled during boom times from 1926 to 1929 in the Greater Seminole Area are inclined to ignore this factor and are completely astounded at its significance and the importance attached to it in this area. During the boom drilling days in this region the one idea was to "get the hole down." Maximum weight was carried on the rotary bits to obtain the fastest drilling speed possible, resulting in deviation from the vertical of almost unbelievable and incredible amounts in many wells now producing in Greater Seminole. Angular deviations of 20, 30 and 40 degrees are frequently encountered, and in at least one case a 45-deg. deviation of the drilled hole from the vertical is reported. Such crooked holes obviously resulted in much excess drilling, and very strange indeed are the results frequently obtained if this factor is not taken into consideration. Thus it is that in one well the Upper Wilcox Sand may be reported by the well log to be several hundred feet different in depth from its immediate offset, whereas proper compensations for the

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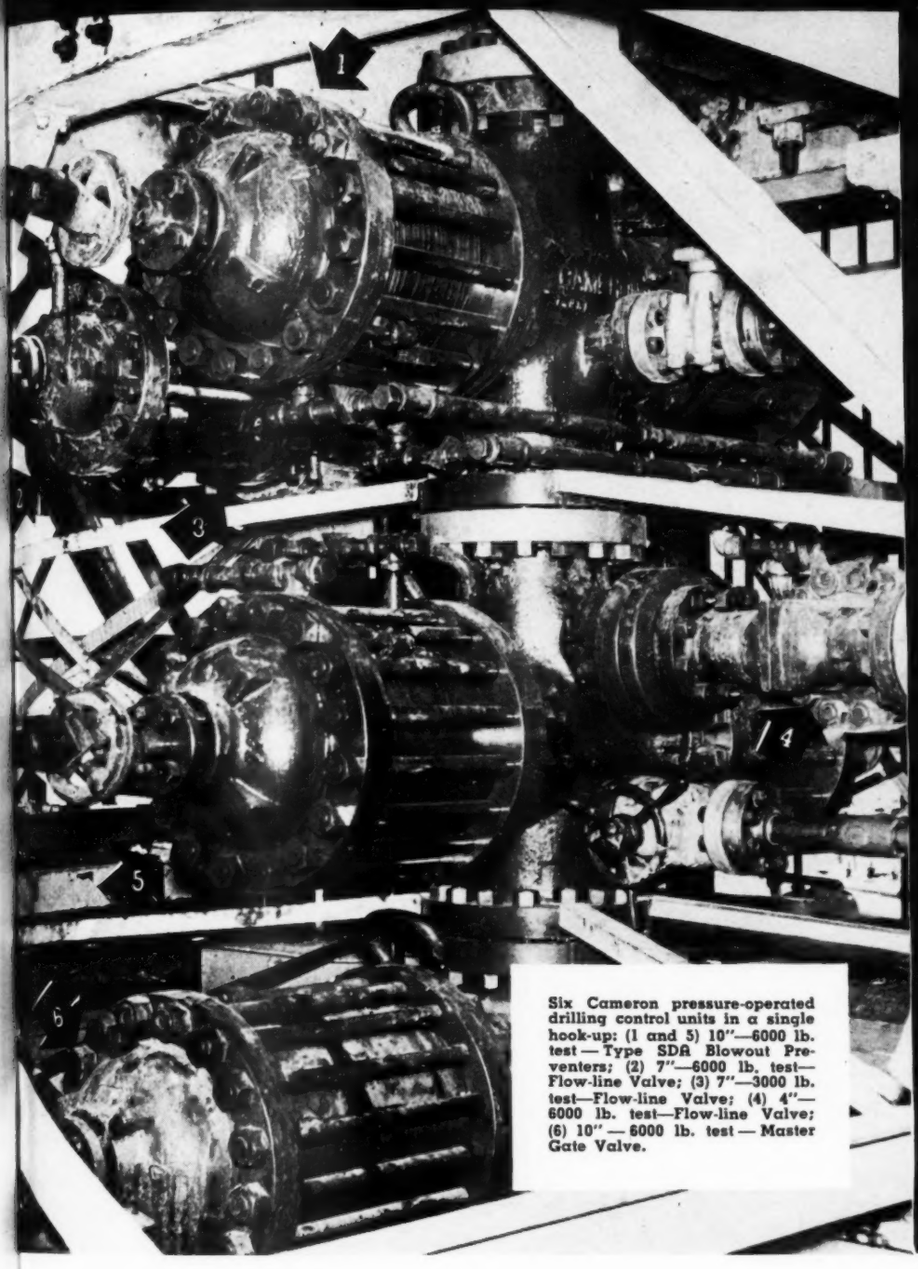

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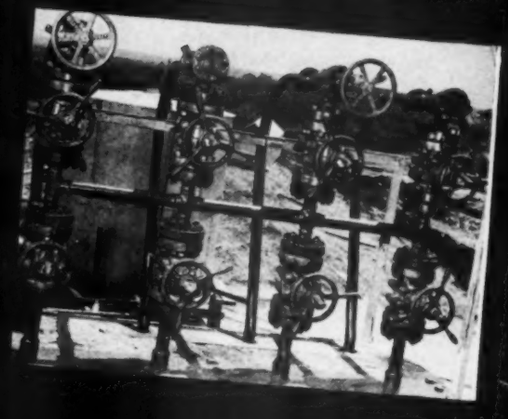

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surface elevations and vertical corrections will reveal that the two wells have virtually the same structural position. In order to correlate data from different wells in the same vicinity it is necessary to refer the wells to the actual vertical depth required to reach a certain geological marker from a common datum plane. The vertical correction of individual wells in the Greater Seminole Area varies from less than 1 ft. to the order of magnitude of the surface elevation of the well, the largest one with which the writer came in contact being 767 ft. in a locality where the surface elevation was approximately 950 ft. From this it can be seen that the importance of knowing the vertical correction of a given oil well in the Greater Seminole Area is greater than that of knowing the surface elevation, as a reasonably accurate estimate of the latter can be made from information obtained from other wells in the same general vicinity. No intelligent correlation of the various wells in a pool from a geological standpoint can be made, however, without definite knowledge of both these factors. Table 1 presents a list of representative vertical corrections of various oil wells located throughout the Greater Seminole Area in order to show the magnitude of this factor and emphasize the importance that should be attached to it in this area.

The vertical correction can be obtained by measuring the deviation of an oil well at various intervals and computing the true vertical depth. This is seldom necessary at the present time, however, as in general the vertical corrections of the majority of old oil wells in the Greater Seminole Area have already been determined from well surveys of the acid-bottle type made during drilling. This information is very difficult to obtain from the various companies in this area. Many are very reluctant to divulge this information, and some regard it as strictly confidential and will not issue it to outsiders. Along this line it is a matter of interest to note the statement of Uren[1] that in the development of an area free exchange of subsurface information among the various interested companies will work for the general benefit of all concerned. It has been the writer's experience that in many cases this is an idealized condition far removed from the practical circumstances encountered, and certainly this statement is true as regards the vertical corrections of oil wells in the Greater Seminole Area.

[1]*Petroleum Production Engineering—Oil Field Development*, by Lester C. Uren. Published by McGraw-Hill Book Co., New York (1934), p. 76.

Horizontal Displacement

The horizontal displacement of the bottom of the hole is one factor concerning which no information is available in the case of old wells drilled during the boom times. The excessive angular deviations known to exist in many of the old wells have undoubtedly resulted in horizontal displacements of considerable magnitude. This factor cannot be evaluated with any degree of accuracy, but its maximum magnitude can be determined from the old acid-bottle type of well surveys that were run in this area if we assume all deviation have occurred in one plane and are cumulative in effect. It is at once evident that these two assumptions undoubtedly deviate from the facts in a majority of cases; however, they do give an idea of the magnitude of this factor and permit one to understand why it is impossible to be too specific and exact concerning the actual location of the bottom of the hole with respect to the surface location of the oil well. Theoretically this information could be obtained by running directional surveys on these wells, and thus determining the actual three-dimensional profile of the well bore. Practically, however, this is not economically justified in many instances; in some wells it would probably be physically impossible to run a survey due to present condition of the well. For these reasons it is very doubtful if any appreciable amount of information regarding this factor will ever be available for engineers engaged in reconditioning the older wells in the Greater Seminole Area.

Figs. 1 and 2 graphically depict the importance of the horizontal displacement of the bottom of the hole and the uncertainty that exists regarding this factor. Fig. 1 shows the possible vertical profile of a typical old oil well having an important vertical correction.

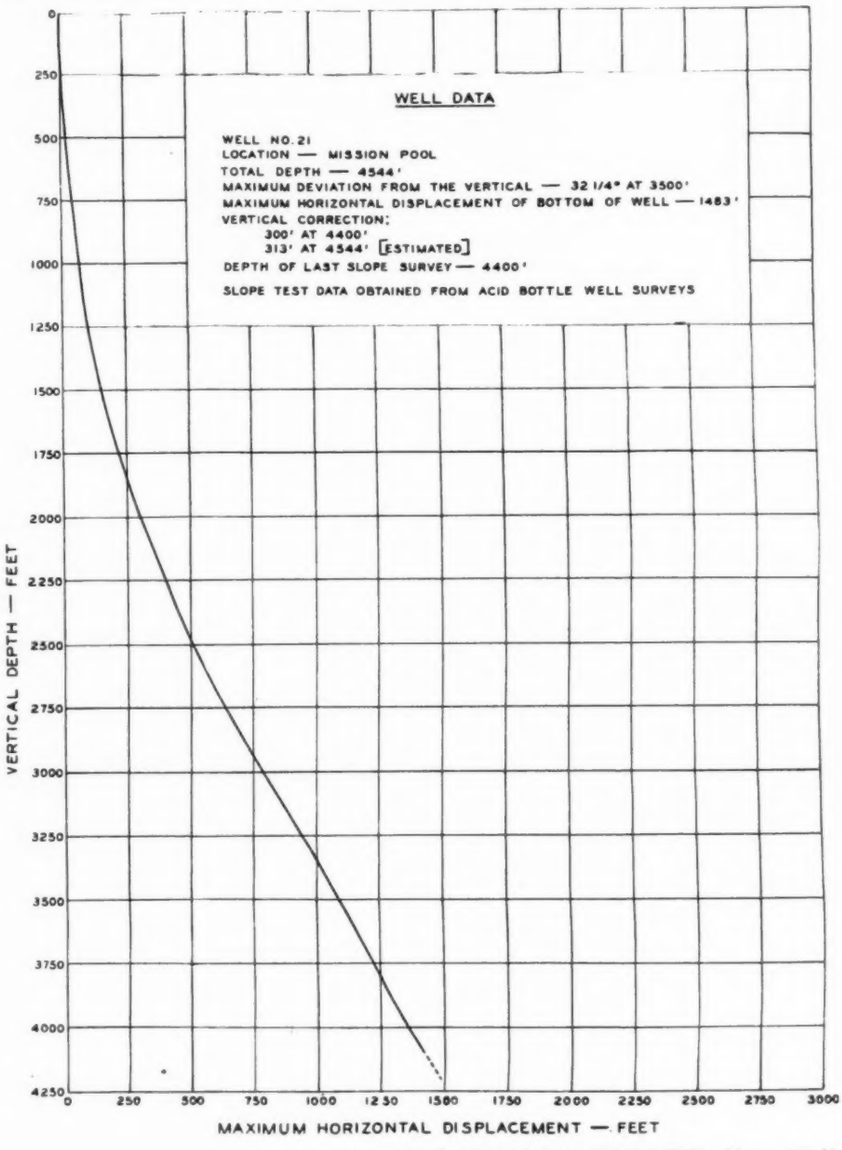

Fig. 1. Hypothetical vertical profile of well having important vertical correction

This profile was plotted by making the two assumptions stated above: (1) all deviations occurred in one plane, (2) all deviations were cumulative in effect. Fig. 2 is a plan view showing the possible location of the bottom of the hole of the same well considered in Fig. 1. This sketch shows the size of the area that might contain the location of the bottom of the hole.

Although the two assumptions stated above are undoubtedly not true in many cases, they do give the maximum possible displacement, and show why it is so frequently impossible to correlate structural geological positions with any degree of certainty.

Producing Formation

Data concerning the producing formation are generally quite fragmentary. Even under the most ideal conditions, and employing rigid control of drilling practice in modern wells it is seldom that all the desired information about a producing formation is available. One can judge therefore what confronts the engineer who seeks information concerning a producing formation in the case of wells drilled many years ago without adequate, and very frequently with virtually no supervision or control. The proper collection and systematic arrangement of data of this type are impossible under these conditions. The more important items that theoretically should be available but which in actual practice so seldom are, except in an incomplete form, are discussed below.

Top of Upper Wilcox Sand

The top of the formation will reveal the geologic structural location of the well with respect to its offset wells. In general a high structural position should be conducive to reconditioning with due regard for other subsurface conditions. In the case of wells drilled by companies having a well-organized field geological department this information is generally available, as it has been customary for many years in drilling wells to exert considerable effort to determine when a given producing formation is first reached. If the wells were initially completed by companies who possessed inadequate geological departments these data may sometimes be of very doubtful accuracy, having frequently been determined by drillers, lease foremen, or other persons not especially trained in geological work. Here it should be restated that unless the vertical corrections of the wells in question are known, the field data regarding the location of the top of the producing formation in the various wells will be devoid of all value.

Amount of Penetration

The amount by which the well penetrated the formation has a very material bearing upon the results that can be obtained by shooting. Insufficient penetration may limit the effects of the explosion so that full benefits are not obtained. In the early days of drilling in the Greater Seminole Area an almost abnormal fear of bottom-hole water encroachment existed, with the result that many wells merely tapped or only very slightly penetrated the Upper Wilcox Sand. In other cases where the amount of penetration is sufficiently great to result in the well's penetrating the water-bearing portions of the formation it is frequently necessary to anchor the shot off bottom a sufficient distance to insure that the effects of the explosive will not be transmitted undiminished to this part of the reservoir and result in a greatly increased rate of water production. It is frequently difficult or impossible to obtain the exact amount of penetration that a given well has in the Upper Wilcox Sand.

Best Saturated Portion of Formation

The location of the best saturated portion of the penetrated formation is a very important factor in determining the size, location, and amount of concentration of the shot. Where satisfactory saturation exists throughout the penetrated portion, it may be desirable to place the shot so that the effects will be distributed over the linear distance of the penetration of the sand. Again, where only a small portion has sufficient saturation, the shot may be concentrated in a shorter linear distance and detonated opposite the region offering the most promise, thus preventing the effect of the explosion from being wasted on barren or water-bearing regions and permitting the use of a smaller size shot to accomplish the desired results.

(*Note:* To be continued in an early issue.)

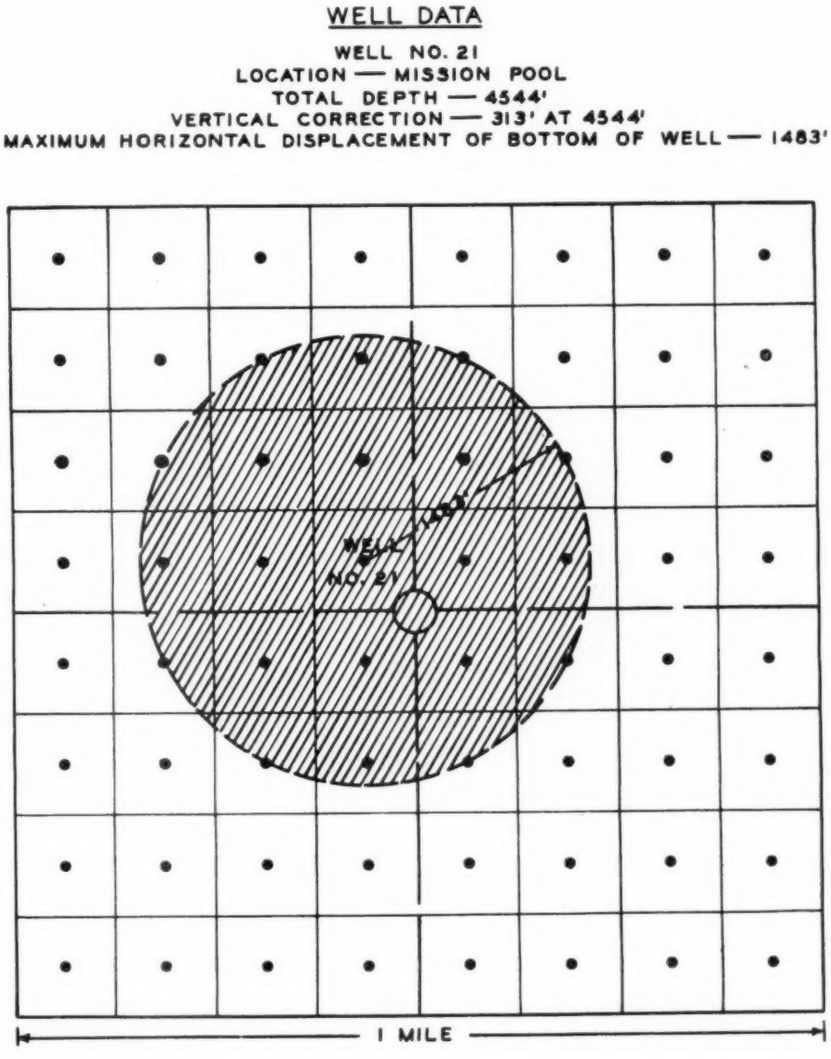

Fig. 2. Area within which bottom of crooked hole could be located

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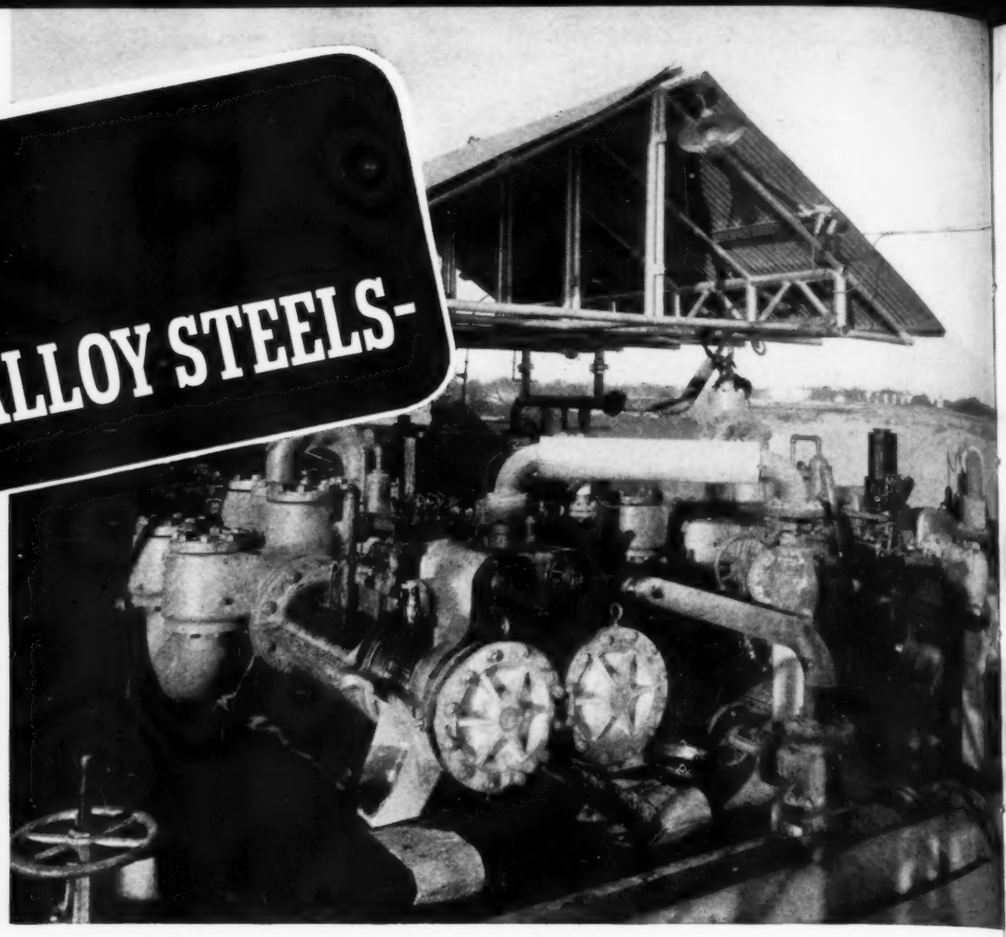

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RISE IN FLUID LEVEL, ETC., DUE TO RUNNING 1¼-IN. EXTERNAL-UPSET TUBING IN WELL FLUID

Diameter of outer string or open hole, in.	Internal diameter of outer string or open hole, in.	Volume[1] contained in outer string or open hole		Volume[1] contained in annular space		Volume[1] in well bore when tubing is in hole (volume in annulus plus volume in tubing)		For every 100 ft. of tubing run in fluid, fluid level will be raised:	
		gal.	bbl.	gal.	bbl.	gal.	bbl.	in annular space when lower end of tubing is closed	in well bore when lower end of tubing is open
Tubing strings									
Non-upset									
2½	2.441	24.31	0.579	12.93	0.308	20.70	0.443	88– 1	1–9
3	2.992	36.52	.870	25.14	.599	32.91	.784	45– 3	1–1
3	2.922	34.84	.829	23.46	.558	31.23	.744	48– 6	1–2
3½	3.548	51.36	1.223	39.98	.952	47.75	1.137	28– 6	0–9
4	3.958	63.92	1.522	52.54	1.251	60.31	1.436	21– 8	0–7
Upset									
2½	2.441	24.31	0.579	12.93	0.308	20.70	0.493	88– 1	1–9
3	2.992	36.52	.870	25.14	.599	32.91	.784	45– 3	1–1
3½	3.476	49.30	1.174	37.92	.903	45.69	1.088	30 0	0-9
4	3.958	63.92	1.522	52.54	1.251	60.31	1.436	21– 8	0–7
Casing strings[2]									
4½	4.090	68.25	1.625	56.87	1.354	64.64	1.539	20– 0	0–7
4½	3.920	62.69	1.493	51.31	1.222	59.08	1.407	22– 2	0–7
5	4.560	84.84	2.020	73.46	1.749	81.23	1.934	15– 6	0–5
5	4.276	74.60	1.776	63.22	1.505	70.99	1.690	18– 0	0–6
5½	5.044	103.8	2.471	92.42	2.200	100.2	2.386	12– 4	0–4
5½	4.670	88.98	2.119	77.60	1.848	85.37	2.033	14– 8	0–5
6	5.524	124.5	2.964	113.1	2.693	120.9	2.879	10– 1	0–4
6	5.240	112.0	2.667	100.6	2.396	108.4	2.581	11– 4	0–4
6⅝	6.135	153.6	3.657	142.2	3.386	145.0	3.452	8– 0	0–3
6⅝	5.675	131.4	3.129	120.0	2.858	127.8	3.043	9– 6	0–3
7	6.538	174.4	4.152	163.0	3.881	170.8	4.067	7– 0	0–3
7	5.920	143.0	3.405	131.6	3.134	139.4	3.319	8– 8	0–3
7⅝	7.125	207.1	4.931	195.7	4.660	203.5	4.845	5–10	0–2
7⅝	6.625	179.1	4.624	167.7	3.993	175.5	4.179	6– 9	0–2
8⅝	8.097	267.5	6.369	256.1	6.098	263.9	6.283	4– 5	0–2
8⅝	7.511	230.2	5.481	218.8	5.210	226.6	5.395	5– 2	0–2
9⅝	9.063	335.1	7.979	323.7	7.708	331.5	7.893	3– 6	0–1(+)
9⅝	8.535	297.2	7.076	285.8	6.805	293.6	6.990	4– 0	0–1(+)
10¾	10.192	423.8	10.090	412.4	9.819	420.2	4.762	2– 9	0–1(+)
10¾	9.760	388.7	9.255	377.3	8.984	385.1	9.169	3– 0	0–1(–)
11¾	11.150	507.2	12.076	495.8	11.805	503.6	11.990	2– 4	0–1(–)
11¾	10.772	473.4	11.271	462.0	11.000	469.8	11.186	2– 6	0–1(–)
13⅜	12.715	659.6	15.705	648.2	15.434	656.0	15.619	1– 9	0–1(–)
13⅜	12.347	622.0	14.810	610.6	14.539	618.4	14.724	1–10	0–1(–)
Open hole (bit size)[3]									
2⅞	2.875	33.73	0.803	22.35	0.532	30.12	0.717	50–11	1–2
3⅞	3.875	61.27	1.459	49.89	1.188	57.66	1.373	22–10	0–7
4¼	4.250	73.70	1.755	62.32	1.484	70.09	1.667	18– 3	0–6
4¾	4.750	92.06	2.192	80.68	1.921	88.45	2.106	14– 1	0–5
5⅝	5.675	131.4	3.129	120.0	2.857	127.8	3.043	9– 6	0–3
6	6.000	146.9	3.498	135.5	3.226	143.3	3.412	8– 5	0–3
6⅛	6.125	153.1	3.645	141.7	3.374	149.5	3.560	8– 0	0–3
6½	6.500	172.4	4.105	161.0	3.833	168.8	4.019	7– 1	0–3
6¾	6.750	185.9	4.426	174.5	4.155	182.3	4.341	6– 6	0–2
7	7.000	199.9	4.760	188.5	4.488	196.3	4.674	6– 0	0–2
7½[4]	7.500	229.5	5.464	218.1	5.193	225.9	5.379	5– 3	0–2
7¾[4]	7.750	245.1	5.836	233.7	5.564	241.5	5.750	4–10	0–2
8½[4]	8.500	294.8	7.019	283.4	6.748	291.2	6.933	4– 0	0–1(+)
9¾[4]	9.750	387.9	9.236	376.5	8.964	384.3	9.150	3– 0	0–1(+)
10⅝	10.625	460.6	10.967	449.2	10.695	457.0	10.881	2– 6	0–1(–)

The 1¼-in. external-upset tubing has a calculated weight of 2.35 lb. per ft. (including a coupling spaced every 20 ft.). The volume displaced by 100 ft. of tubing and 5 couplings: (1) by the steel itself (with lower end of tubing open), 0.3591 gal. or 0.00855 bbl.; (2) by the pipe (with lower end of tubing closed), 11.38 gal. or 0.2709 bbl. The volume contained within 100 ft. of the tubing is 7.768 gal. or 0.1850 bbl.

[1]All volume figures are based on 100 ft. of depth; multiply to convert to other depths or lengths. For example, if the depth or length is 5196 ft., multiply by 51.96.

[2]Only maximum and minimum weights of pipe are shown for each casing size.

[3]Variation is diameter of open hole due to caving, etc., is disregarded.

[4]This diameter is an average of the two bit sizes ⅛ in. larger and smaller, respectively.

Table suggested by George B. Rice, Butler & Horne Drilling Co., Dallas, Texas.

THUMBS UP for HAZARD WIRE LINES

HAZARD LAY-SET Preformed Green Strand is more and more becoming the standard rotary drilling line in all fields because it lasts longer—resists whipping—makes possible faster round trips. LAY-SET Preformed handles easier, spools better, *is safer*. Hazard LAY-SET has proved its superiority over and over again in practically *all* fields. And when you use Green Strand LAY-SET, you know it is made of Improved Plow Steel—the long-life, greater dollar value line.

HAZARD Nonparell Brand has long been preferred by cable tool drillers. This is one of the lines that is backed by nearly a century of wire rope making experience. It is known to "old timers" and younger drillers, tool pushers and superintendents as the line that "gets the job done." Hazard men are wire line engineers. They know the exact wire rope construction and grade for each application. They will be glad of the opportunity to help you get greater dollar value.

★ *The Green Strand Identifies Hazard Wire Ropes Made of Improved Plow Steel*

HAZARD WIRE ROPE DIVISION • *Established 1846* • WILKES-BARRE • PENNSYLVANIA
AMERICAN CHAIN & CABLE COMPANY, INC.
BRANCHES OR DISTRIBUTORS IN ALL IMPORTANT OIL FIELDS

GREEN SIGNIFIES SAFETY

CORRELATION INDEX[1] (C. I.) VALUES IN CRUDE-OIL ANALYSES[2]

Specific gravity, G, of fraction at 60°F/60°F	Fraction no.[3]	Constant for fraction[4]	Temperature limits of fraction, °C.	Average volumetric boiling point[5] of fraction, °K	Correlation index (C. I.) values — Specific gravity—third decimal place									
					0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.650	2	309.9	50– 75	331	.....	.....	.....	.....	.....	0.8	0.9	1.3	1.8	2.3
0.660	2				2.7	3.2	3.7	4.2	4.6	5.1	5.6	6.1	6.5	7.0
0.670	2				7.5	8.0	8.4	8.9	9.4	9.8	10.	11.	11.	12.
.670	3	319.8	75–100	355	.....	.....	.....	.....	.....	.....	0.4	0.9	1.4	1.8
0.680	2				12.	13.	13.	14.	14.	15.	15.	16.	16.	17.
.680	3				2.3	2.8	3.3	3.7	4.2	4.7	5.2	5.6	6.1	6.6
0.690	2				17.	17.	18.	18.	19.	19.	20.	20.	21.	21.
.690	3				7.1	7.5	8.0	8.5	8.9	9.4	10.	10.	11.	11.
.690	4	328.8	100–125	380	.....	.....	.....	.....	.....	0.4	0.9	1.4	1.8	2.3
0.700	2				22.	22.	23.	23.	24.	24.	25.	25.	26.	26.
.700	3				12.	12.	13.	13.	14.	14.	15.	15.	16.	16.
.700	4				2.8	3.3	3.7	4.2	4.7	5.2	5.6	6.1	6.6	7.1
0.710	2				26.	27.	27.	28.	28.	29.	29.	30.	30.	31.
.710	3				17.	17.	18.	18.	18.	19.	19.	20.	20.	21.
.710	4				7.5	8.0	8.5	8.9	9.4	9.9	10.	11.	11.	12.
.710	5	336.4	125–150	404	.....	0.4	0.9	1.3	1.8	2.3	2.8	3.2	3.7	4.2
0.720	2													
.720	3				21.	22.	22.	23.	23.	24.	24.	25.	25.	26.
.720	4				12.	13.	13.	14.	14.	15.	15.	16.	16.	17.
.720	5				4.7	5.1	5.6	6.1	6.6	7.0	7.5	8.0	8.5	8.9
.720	6	343.2	150–175	428	.....	.....	.....	.....	.....	0.2	0.7	1.2	1.7	2.1
0.730	3				26.	27.	27.	27.	28.	28.	29.	29.	30.	30.
.730	4				17.	18.	18.	18.	19.	19.	20.	20.	21.	21.
.730	5				9.4	9.9	10.	11.	11.	12.	12.	13.	13.	14.
.730	6				2.6	3.1	3.5	4.0	4.5	5.0	5.4	5.9	6.4	6.9
.730	7	394.4	175–200	453	.....	.....	.....	.....	.....	.....	.....	.....	0.2	0.7
0.740	3				31.	31.	32.	32.	33.	33.	34.	34.	35.	35.
.740	4				22.	22.	23.	23.	24.	24.	25.	25.	26.	26.
.740	5				14.	15.	15.	16.	16.	17.	17.	18.	18.	18.
.740	6				7.3	7.8	8.3	8.8	9.2	9.7	10.	11.	11.	12.
.740	7				1.1	1.6	2.1	2.6	3.0	3.5	4.0	4.5	4.9	5.4
0.750	3				36.	36.	36.	37.	37.	38.	38.	39.	39.	40.
.750	4				27.	27.	27.	28.	28.	29.	29.	30.	30.	31.
.750	5				19.	19.	20.	20.	21.	21.	22.	22.	23.	23.
.750	6				12.	13.	13.	14.	14.	14.	15.	15.	16.	16.
.750	7				5.9	6.3	6.8	7.3	7.8	8.2	8.7	9.2	10.	10.
.750	8	355.0	200–225	478	0.3	0.7	1.2	1.7	2.2	2.6	3.1	3.6	4.1	4.5
0.760	3				40.	41.	41.	42.	42.	43.	43.	43.	44.	44.
.760	4				31.	32.	32.	33.	33.	34.	34.	35.	35.	36.
.760	5				24.	24.	25.	25.	26.	26.	27.	27.	27.	28.
.760	6				17.	17.	18.	18.	19.	19.	20.	20.	21.	21.
.760	7				11.	11.	12.	12.	13.	13.	14.	14.	14.	15.
.760	8				5.0	5.5	6.0	6.4	6.9	7.4	7.9	8.3	8.8	9.3
.760	9	360.3	225–250	504	.....	0.2	0.7	1.1	1.6	2.1	2.6	3.0	3.5	4.0
0.770	4				36.	36.	37.	37.	38.	38.	39.	39.	40.	40.
.770	5				28.	29.	29.	30.	30.	31.	31.	32.	32.	33.
.770	6				22.	22.	23.	23.	23.	24.	24.	25.	25.	26.
.770	7				15.	16.	16.	17.	17.	18.	18.	19.	19.	20.
.770	8				9.7	10.	11.	11.	12.	12.	13.	13.	14.	14.
.770	9				4.4	4.9	5.4	5.9	6.3	6.8	7.3	7.8	8.2	8.7
.770	10	365.0	250–275	530	.....	0.2	0.7	1.2	1.6	2.1	2.6	3.1	3.5	4.0
0.780	4				41.	41.	42.	42.	43.	43.	43.	44.	44.	45.
.780	5				33.	34.	34.	35.	35.	36.	36.	36.	37.	37.
.780	6				26.	27.	27.	28.	28.	29.	29.	30.	30.	31.
.780	7				.20	21.	21.	22.	22.	23.	23.	23.	24.	24.
0.780	8				15.	15.	15.	16.	16.	17.	17.	18.	18.	19.
.780	9				9.2	9.7	10.	11.	11.	12.	12.	13.	13.	13.
.780	10				4.5	5.0	5.4	5.9	6.4	6.9	7.3	7.8	8.3	8.7
.780	11	369.0	To 200[6]	554[7]	0.5	1.0	1.4	1.9	2.4	2.9	3.3	3.8	4.3	4.7
.780	12	372.8	200–225	579	.....	.....	.....	.....	.....	.....	.....	.....	0.5	0.9
.780														

[1]The correlation index is a number whose magnitude indicates certain characteristics of a crude-oil distillation fraction. If the fraction be from a paraffin-base crude oil, its index will be small; if from intermediate and naphthene-base crude oils the indexes will be increasingly larger.

[2]When analyses are made by the Bureau of Mines Hempel method.

[3]In the Hempel method, all hydrocarbon fractions are designated by number, based on boiling range, from 1 to 15, inclusive.

[4]The constant for each fraction represents the first and third terms (48640/K — 456.8) in the equation: C.I. = 48640/K + 473.7G — 456.8, in which C.I. is the correlation index, K is the average boiling point of the fraction in degrees Kelvin (degrees C. + 273), and G is the specific gravity of the fraction at 60°F./60°F.

[5]Uncorrected for emergent stem.

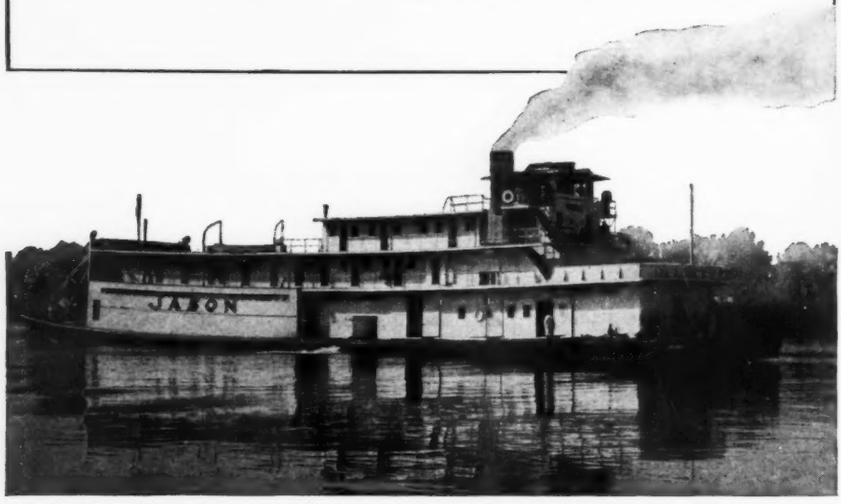
[6]Fractions 2 to 10 are at atmospheric pressure; fractions 11 to 15 are at 40 mm. pressure.

[7]Temperatures for fractions 11 to 15 are calculated at atmospheric pressure.

Table (with additions and rearrangement) is taken largely from *Correlation Index To Aid In Interpreting Crude-Oil Analyses* by Harold M. Smith, U. S. Bureau of Mines Technical Paper 610, published in 1940.

IN THE NEWS

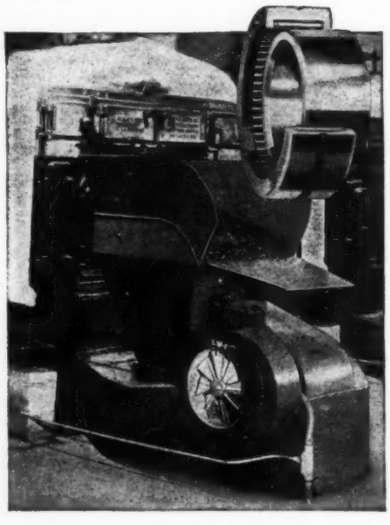
WITH BANTAM BEARINGS



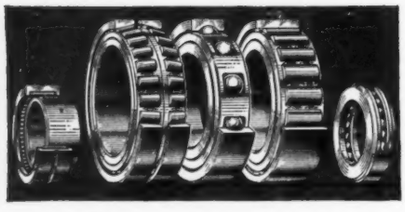
THE MISSISSIPPI STEAMBOAT of today combines the advances of up-to-the-minute engineering design with the long-recognized advantages of the paddle-wheel steamer for shallow river service. Among the newest of river boats is the *Jason*, designed and built by Marietta Manufacturing Company. In keeping with its progressive design, Bantam Quill Bearings are used on the cam rollers that actuate the valves of the *Jason's* engines.

FOR LONGER BEARING LIFE, Bantam employs bronze cages in many of its bearings, because the bronze cage surfaces are long-lasting, and provide a safeguard against wear on the steel rollers. Photo shows welding of the bronze cage for a Bantam Precision Tapered Roller Bearing.

HIGHER SPEEDS AND HEAVIER LOADS are being constantly encountered in modern drilling practice. Oil Well Supply Company's new 17½-inch Oil-bath Rotary, designed for speeds up to 400 RPM and depths to 7,500 feet, is provided with a Bantam Angular Contact Bearing, which takes both thrust and radial loads, permits rotary table operation at high speeds.



HEAT, GRIT, AND HEAVY LOADS are normal operating conditions for mechanical stokers, which must perform reliably even if neglected or overloaded. Combustion Engineering, Inc. assures long life and efficient operation of its Skelly Stoker Units by installing Bantam Quill Bearings at vital points. For further information on this compact, high-capacity anti-friction bearing, write for Bulletin P-104.



EVERY MAJOR TYPE of anti-friction bearing is included in Bantam's line—straight roller, tapered roller, needle, and ball. Bantam serves every industry with a wide range of standard bearings that meet many normal requirements. Bantam engineers offer unbiased advice on selection of standard bearings—and design custom-built bearings in large sizes or special types for unusual conditions. If you have an exceptionally difficult bearing problem, TURN TO BANTAM.

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

Static Press.
300-395 lb.

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																			
	300	305	310	315	320	325	330	335	340	345	350	355	360	365	370	375	380	385	390	395
2	25.10	25.30	25.49	25.69	25.88	26.07	26.26	26.46	26.64	26.82	27.01	27.21	27.38	27.56	27.74	27.93	28.10	28.28	28.45	28.63
4	35.50	35.78	36.06	36.34	36.60	36.88	37.14	37.42	37.68	37.94	38.20	38.48	38.72	38.98	39.24	39.50	39.74	40.00	40.24	40.50
6	43.47	43.81	44.16	44.50	44.82	45.16	45.48	45.82	46.14	46.46	46.78	47.12	47.41	47.73	48.05	48.37	48.66	48.98	49.27	49.59
8	50.20	50.59	50.99	51.38	51.75	52.15	52.52	52.91	53.28	53.65	54.01	54.41	54.75	55.12	55.49	55.85	56.19	56.56	56.90	57.27
10	56.13	56.57	57.01	57.45	57.86	58.31	58.72	59.16	59.57	59.98	60.39	60.84	61.22	61.63	62.04	62.45	62.83	63.24	63.62	64.03
12	61.49	61.97	62.46	62.94	63.39	63.88	64.33	64.81	65.26	65.71	66.16	66.65	67.06	67.51	67.96	68.41	68.83	69.28	69.70	70.15
14	66.42	66.94	67.47	67.99	68.48	69.00	69.49	70.01	70.50	70.99	71.47	72.00	72.45	72.93	73.42	73.90	74.35	74.84	75.29	75.78
16	71.00	71.56	72.12	72.68	73.20	73.76	74.28	74.84	75.36	75.88	76.40	76.96	77.44	77.96	78.48	79.00	79.48	80.00	80.48	81.00
18	75.31	75.91	76.50	77.10	77.65	78.24	78.79	79.39	79.94	80.49	81.04	81.64	82.14	82.70	83.25	83.80	84.31	84.86	85.37	85.92
20	79.38	80.00	80.63	81.26	81.84	82.46	83.05	83.67	84.25	84.83	85.42	86.04	86.58	87.16	87.74	88.32	88.86	89.44	89.98	90.56
21	81.35	81.99	82.63	83.27	83.87	84.51	85.11	85.75	86.34	86.94	87.54	88.18	88.73	89.32	89.92	90.51	91.06	91.66	92.21	92.81
22	83.25	83.90	84.56	85.22	85.83	86.48	87.09	87.75	88.36	88.97	89.58	90.24	90.80	91.41	92.02	92.63	93.19	93.80	94.36	94.97
23	85.13	85.80	86.47	87.14	87.77	88.44	89.06	89.73	90.36	90.98	91.60	92.28	92.85	93.47	94.10	94.72	95.30	95.92	96.50	97.12
24	86.97	87.64	88.33	89.01	89.65	90.34	90.97	91.66	92.30	92.93	93.57	94.26	94.84	95.48	96.12	96.76	97.34	97.98	98.57	99.20
25	88.75	89.45	90.15	90.85	91.50	92.20	92.85	93.55	94.20	94.85	95.50	96.20	96.80	97.45	98.10	98.75	99.35	100.0	100.6	101.3
26	90.51	91.22	91.93	92.65	93.31	94.03	94.69	95.40	96.07	96.73	97.39	98.10	98.72	99.38	100.0	100.7	101.3	102.0	102.6	103.3
27	92.23	92.96	93.68	94.41	95.09	95.81	96.49	97.22	97.89	98.57	99.24	99.97	100.6	101.3	101.9	102.6	103.2	103.9	104.5	105.2
28	93.93	94.67	95.41	96.16	96.84	97.58	98.27	99.01	99.70	100.4	101.1	101.8	102.5	103.1	103.8	104.5	105.2	105.8	106.5	107.2
29	95.76	96.52	97.27	98.03	98.73	99.48	100.2	100.9	101.6	102.3	103.0	103.8	104.4	105.1	105.8	106.6	107.2	107.9	108.5	109.2
30	97.22	97.98	98.75	99.52	100.2	101.0	101.7	102.5	103.2	103.9	104.6	105.4	106.0	106.7	107.5	108.2	108.8	109.5	110.2	110.9
31	98.83	99.61	100.4	101.2	101.9	102.7	103.4	104.2	104.9	105.6	106.3	107.1	107.8	108.5	109.2	110.0	110.6	111.4	112.0	112.8
32	100.4	101.2	102.0	102.8	103.5	104.3	105.1	105.8	106.6	107.3	108.0	108.8	109.5	110.3	111.0	111.7	112.4	113.1	113.8	114.6
33	102.0	102.8	103.6	104.4	105.1	105.9	106.7	107.5	108.2	109.0	109.7	110.5	111.2	112.0	112.7	113.5	114.2	114.9	115.6	116.3
34	103.5	104.3	105.1	105.9	106.7	107.5	108.3	109.1	109.9	110.6	111.4	112.2	112.9	113.6	114.4	115.2	115.9	116.6	117.3	118.1
35	105.0	105.8	106.7	107.5	108.3	109.1	109.9	110.7	111.5	112.2	113.0	113.8	114.5	115.3	116.1	116.8	117.6	118.3	119.0	119.8
36	106.5	107.3	108.2	109.0	109.8	110.6	111.4	112.3	113.0	113.8	114.6	115.4	116.2	116.9	117.7	118.5	119.2	120.0	120.7	121.5
37	108.0	108.8	109.7	110.5	111.3	112.2	113.0	113.8	114.6	115.4	116.2	117.0	117.8	118.6	119.3	120.1	120.9	121.7	122.4	123.2
38	109.4	110.3	111.1	112.0	112.8	113.7	114.5	115.3	116.1	116.9	117.7	118.6	119.3	120.1	120.9	121.7	122.5	123.3	124.0	124.8
39	110.8	111.7	112.6	113.5	114.3	115.2	116.0	116.8	117.7	118.5	119.3	120.2	120.9	121.7	122.5	123.3	124.1	124.9	125.6	126.5
40	112.3	113.2	114.0	114.9	115.7	116.6	117.5	118.3	119.2	120.0	120.8	121.7	122.5	123.3	124.1	124.9	125.7	126.5	127.3	128.1
41	113.7	114.5	115.4	116.3	117.2	118.1	118.9	119.8	120.6	121.5	122.3	123.2	124.0	124.8	125.6	126.5	127.2	128.1	128.8	129.7
42	115.0	115.9	116.9	117.8	118.6	119.5	120.4	121.3	122.1	122.9	123.8	124.7	125.5	126.3	127.2	128.0	128.8	129.6	130.4	131.2
43	116.4	117.3	118.2	119.1	120.0	120.9	121.8	122.7	123.5	124.4	125.2	126.2	126.9	127.8	128.6	129.5	130.3	131.1	131.9	132.8
44	117.7	118.7	119.6	120.5	121.4	122.3	123.2	124.1	125.0	125.8	126.7	127.6	128.4	129.3	130.1	131.0	131.8	132.7	133.5	134.3
45	119.1	120.0	120.9	121.9	122.8	123.7	124.6	125.5	126.4	127.3	128.1	129.1	129.9	130.7	131.6	132.5	133.3	134.2	135.0	135.8
46	120.4	121.3	122.3	123.2	124.1	125.1	125.9	126.9	127.8	128.7	129.5	130.5	131.3	132.2	133.1	133.9	134.8	135.6	136.5	137.3
47	121.7	123.3	123.6	124.6	125.5	126.4	127.3	128.3	129.2	130.1	130.9	131.9	132.7	133.6	134.5	135.4	136.2	137.1	137.9	138.8
48	123.0	123.9	124.9	125.9	126.8	127.8	128.7	129.6	130.5	131.4	132.3	133.3	134.1	135.0	135.9	136.8	137.7	137.6	139.4	140.3
49	124.3	125.2	126.2	127.2	128.1	129.1	130.0	131.0	131.9	132.8	133.7	134.7	135.5	136.4	137.3	138.3	139.1	140.0	140.8	141.8
50	125.5	126.5	127.5	128.5	129.4	130.4	131.3	132.3	133.2	134.1	135.1	136.0	136.9	137.8	138.7	139.7	140.5	141.4	142.3	143.2
51	126.8	127.8	128.8	129.8	130.7	131.7	132.6	133.6	134.5	135.5	136.4	137.4	138.2	139.2	140.1	141.0	141.9	142.8	143.7	144.6
52	128.0	129.0	130.0	131.0	132.0	133.0	133.9	134.9	135.9	136.8	137.7	138.7	139.6	140.5	141.5	142.4	143.3	144.2	145.1	146.0
53	129.2	130.2	131.3	132.3	133.2	134.2	135.2	136.2	137.2	138.1	139.0	140.1	140.9	141.9	142.8	143.8	144.7	145.6	146.5	147.4
54	130.4	131.5	132.5	133.5	134.5	135.5	136.5	137.5	138.4	139.4	140.3	141.4	142.3	143.2	144.2	145.1	146.0	147.0	147.8	148.8
55	131.6	132.7	133.7	134.7	135.7	136.8	137.7	138.8	139.7	140.7	141.6	142.7	143.6	144.5	145.5	146.5	147.4	148.3	149.2	150.2
56	132.8	133.9	134.9	136.0	136.9	138.0	139.0	140.0	141.0	142.0	142.9	144.0	144.9	145.8	146.8	147.8	148.7	149.7	150.6	151.5
57	134.0	135.1	136.1	137.2	138.2	139.2	140.2	141.3	142.2	143.2	144.2	145.3	146.2	147.1	148.1	149.1	150.0	151.0	151.9	152.9
58	135.2	136.3	137.3	138.4	139.4	140.4	141.4	142.5	143.5	144.5	145.5	146.5	147.4	148.4	149.4	150.4	151.3	152.3	153.2	154.2
59	136.3	137.4	138.5	139.6	140.6	141.6	142.6	143.7	144.7	145.7	146.7	148.6	148.7	149.7	150.7	151.7	152.6	153.6	154.5	155.5
60	137.5	138.6	139.7	140.7	141.8	142.8	143.8	144.9	145.9	146.9	147.9	149.0	150.0	151.0	152.0	153.0	153.9	154.9	155.8	156.9
61	138.6	139.7	140.8	141.9	142.9	144.0	145.0	146.1	147.1	148.2	149.2	150.3	151.2	152.2	153.2	154.2	155.2	156.2	157.1	158.2
62	139.8	140.9	142.0	143.1	144.1	145.2	146.2	147.3	148.3	149.4	150.4	151.5	152.4	153.5	154.5	155.5	156.5	157.5	158.4	159.4
63	140.9	142.0	143.1	144.2	145.2	146.4	147.4	148.5	149.5	150.6	151.6	152.7	153.7	154.7	155.7	156.8	157.7	158.7	159.7	160.7
64	142.0	143.1	144.2	145.4	146.4	147.5	148.6	149.7	150.7	151.8	152.8	153.9	154.9	155.9	157.0	158.0	159.0	160.0	161.0	162.0
65	143.1	144.2	145.4	146.5	147.5	148.7	149.7	150.8	151.9	152.9	154.0	155.1	156.1	157.1	158.2	159.2	160.2	161.2	162.2	163.3
66	144.2	145.3	146.5	147.6	148.7	149.8	150.9	152.0	153.1	154.1	155.2	156.3	157.3	158.3	159.4	160.4	161.4	162.5	163.5	164.5
67	145.3	146.4	147.6	148.7	149.8	150.9	152.0	153.1	154.2	155.3	156.3	157.5	158.5	159.5	160.6	161.7	162.6	163.7	164.7	165.7
68	146.4	147.5	148.7	149.8	150.9	152.1	153.1	154.3	155.4	156.4	157.5	158.7	159.6	160.7	161.8	162.9	163.8	164.9	165.9	167.0
69	147.4	148.6	149.8	150.9	152.0	153.2	154.3	155.4	156.5	157.6	158.7	159.8	160.8	161.9	163.0	164.1	165.1	166.1	167.1	168.2
70	148.5	149.7	150.9	152.0	153.1	154.3	155.4	156.5	157.6	158.7	159.8	161.0	162.0	163.1	164.2	165.2	166.3	167.3	168.3	169.4
71	149.6	150.7	151.9	153.9	154.2	155.4	156.5	157.7	158.7	159.8	160.9	162.1	163.1	164.2	165.3	166.4	167.4	168.5	169.5	170.6
72	150.6	151.8	153.0	154.2	155.3	156.5	157.6	158.8	159.9	161.0	162.1	163.3	164.3	165.4	166.5	167.6	168.6	169.7	170.7	171.8
73	151.7	152.9	154.0	155.2	156.4	157.4	158.7	159.9	161.0	162.1	163.2	164.4	165.4	166.5	167.6	168.7	169.8	170.9	171.9	173.0
74	152.7	153.9	155.1	156.3	157.4	158.6	159.7	160.9	162.1	163.2	164.3	165.5	166.5	167.7	168.8	169.9	170.9	172.9	173.1	174.2
75	153.7	154.9	156.1	157.4	158.5	159.7	160.8	162.0	163.2	164.3	165.4	166.6	167.7	168.8	169.9	171.0	172.1	173.2	174.2	175.4
76	154.7	156.0	157.2	158.4	159.5	160.8	161.9	163.1	164.2	165.4	166.5	167.7	168.8	169.9	171.0	172.2	173.2	174.4	175.4	176.5
77	155.8	157.0	158.2	159.4	160.6	161.8	163.0	164.2	165.3	166.5	167.6	168.8	169.9	171.0	172.2	173.3	174.4	175.5	176.6	177.7
78	156.8	158.0	159.2	160.5	161.6	162.9	164.0	165.2	166.4	167.5	168.7	169.9	171.0	172.1	173.3	174.4	175.5	176.6	177.7	178.8
79	157.8	159.0	160.3	161.5	162.7	163.9	165.1	166.3	167.4	168.6	169.8	171.0	172.1	173.2	174.4	175.5	176.6	177.8	178.8	180.0
80	158.8	160.0	161.3	162.5	163.7	164.9	166.1	167.3	168.5	169.7	170.8	172.1	173.2	174.3	175.5	176.6	177.7	178.9	180.0	181.1
82	160.7	162.9	163.3	164.5	165.7	167.0	168.2	169.4	170.6	171.8	173.0	174.2	175.3	176.5	177.7	178.8	179.9	181.1	182.2	183.4
84	162.7	164.0	165.2	166.5	167.7	169.0	170.2	171.5	172.7	173.9	175.1	176.3	177.4	179.5	179.8	181.0	182.1	183.3	184.4	185.6
86	164.6	165.9	167.2	168.5	169.7	171.0	172.2	173.5	174.7	175.9	177.1	178.4	179.5	180.8	182.0	183.2	184.3	185.5	186.6	187.8
88	166.5	167.8	169.1	170.5	171.7	173.0	174.2	175.5	176.7	178.0	179.2	180.5	181.6	182.8	184.1	185.3	186.4	187.6	188.7	190.0
90	168.4	169.7	171.1	172.4	173.6	174.9	176.2	177.5	178.7	180.0	181.2	182.5	183.7	184.9	186.1	187.4	188.5	189.7	190.9	192.1
92	170.3	171.6	172.9	174.3	175.5	176.9	178.1	179.5	180.7	182.0	183.2	184.6	185.7	186.9	188.2	189.4	190.6	191.8	193.0	194.2
94	172.1	173.4	174.8	176.2	177.4	178.8	180.0	181.4	182.7	183.9	185.2	186.5	187.7	189.0	190.2	191.5	192.6	193.9	195.1	196.3
96	173.9	175.3	176.7	178.0	179.3	180.7	181.9	183.3	184.6	185.9	187.1	188.5	189.7	191.0	192.2	193.5	194.7	196.0	197.1	198.4
98	175.7	177.1	178.5	179.9	181.2	182.5	183.8	185.2	186.5	187.8	189.1	190.5	191.6	192.9	194.2	195.5	196.7	198.0	199.2	200.5
100	177.5	178.9	180.3	181.7	183.0	184.4	185.7	187.1	188.4	189.7	191.0	192.4	193.6	194.9	196.2	197.5	198.7	200.0	201.2	202.5

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water respectively.

Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.

Table has been condensed to serve field men in approximating meter readings; intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

GET "Steel Discipline"

ON SMALL FIELD AND REFINERY LINES

Put Chapman's 960 in Command

Recruit a uniform line-up of small valves that know how to "toe the mark" in service, on all lines up to 2 inches. Make up a new valve-rollcall with Chapman's list 960 in every position.

For this forged-steel gate valve is a seasoned campaigner that puts to rout the usual needs for constant repairs and replacements . . . maintains perfect operating discipline . . . *and far outlasts any similar type of valve.*

Sizes from ¼ to 2 inches. Pressures up to 800 lb. at 750° F. . . . and cold working pressures up to 1500 lb. Interchangeable rising stem, seat rings and wedge of super-hardened stainless steel. Threaded ends on both inside and outside screw models. Call 960—the number that will draft a full defense force against small-valve troubles throughout your operations. Get in touch *today* with the Chapman plant or the nearest office.

The **CHAPMAN VALVE**
MANUFACTURING COMPANY
INDIAN ORCHARD, MASSACHUSETTS

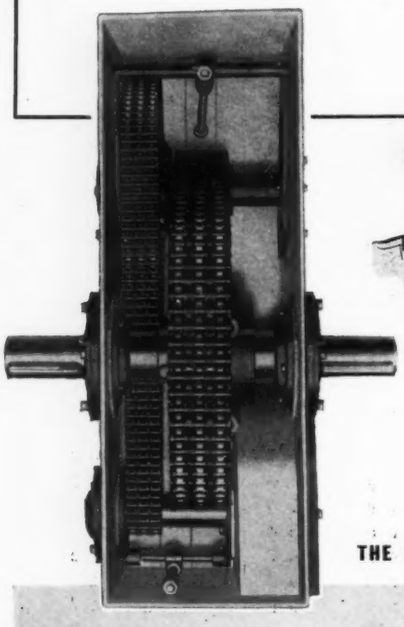
VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 2-IN. AND 3½-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	300	5.0	1.9	1.2	0.9	0.7	0.6	0.5	0.5	0.4
100		10.1	3.9	2.5	1.8	1.5	1.2	1.1	1.0	0.9
150		15.1	5.8	3.7	2.7	2.2	1.8	1.6	1.4	1.3
200		20.1	7.8	4.9	3.7	2.9	2.4	2.2	1.9	1.7
250		25.2	9.7	6.2	4.6	3.7	3.0	2.7	2.4	2.2
300		30.2	11.7	7.4	5.5	4.4	3.6	3.2	2.9	2.6
350		35.2	13.6	8.6	6.4	5.2	4.2	3.8	3.4	3.1
400		40.3	15.6	9.9	7.3	5.6	4.8	4.3	3.9	3.5
50	400	6.7	2.6	1.6	1.2	1.0	0.8	0.7	0.6	0.6
100		13.4	5.1	3.2	2.4	1.9	1.6	1.4	1.2	1.1
150		20.0	7.7	4.8	3.6	2.9	2.4	2.1	1.8	1.7
200		26.7	10.3	6.5	4.8	3.8	3.2	2.8	2.5	2.2
250		33.4	12.8	8.1	6.0	4.8	4.0	3.5	3.1	2.8
300		40.1	15.4	9.7	7.1	5.7	4.8	4.1	3.7	3.3
350		46.8	17.9	11.3	8.3	6.7	5.6	4.8	4.3	3.9
400		53.4	20.5	12.9	9.5	7.6	6.4	5.5	4.9	4.4
50	500	8.3	3.2	2.0	1.5	1.2	1.0	0.8	0.7	0.7
100		16.7	6.4	4.0	2.9	2.3	1.9	1.7	1.5	1.3
150		25.0	9.5	6.0	4.4	3.5	2.9	2.5	2.2	2.0
200		33.3	12.7	8.0	5.9	4.7	3.9	3.4	3.0	2.7
250		41.6	15.9	10.0	7.3	5.8	4.9	4.2	3.7	3.3
300		50.0	19.1	12.0	8.8	7.0	5.8	5.0	4.5	4.0
350		58.3	22.3	13.9	10.3	8.2	6.8	5.9	5.2	4.7
400		66.6	25.4	15.9	11.7	9.3	7.8	6.7	5.9	5.3
50	600	10.0	3.8	2.4	1.7	1.4	1.2	1.0	0.9	0.8
100		19.9	7.6	4.7	3.5	2.8	2.3	1.9	1.7	1.6
150		29.9	11.4	7.1	5.2	4.1	3.5	3.0	2.6	2.3
200		39.9	15.2	9.5	7.0	5.2	4.6	4.0	3.5	3.1
250		49.9	19.0	11.9	8.9	6.9	5.8	5.0	4.4	3.9
300		59.8	22.7	14.2	10.4	8.3	6.9	5.9	5.2	4.7
350		69.8	26.6	16.6	12.2	9.7	8.1	6.9	6.1	5.5
400		79.8	30.4	19.0	13.9	11.0	9.2	7.9	7.0	6.3
50	700	11.6	4.4	2.8	2.0	1.6	1.3	1.1	1.0	0.9
100		23.2	8.8	5.5	4.0	3.2	2.7	2.3	2.0	1.8
150		34.9	13.2	8.3	6.0	4.8	4.0	3.4	3.0	2.7
200		46.5	17.7	11.0	8.1	6.4	5.3	4.6	4.0	3.6
250		58.1	22.1	13.8	10.1	8.0	6.6	5.7	5.0	4.5
300		69.7	26.5	16.5	12.1	9.6	8.0	6.8	6.0	5.4
350		81.3	30.9	19.3	14.1	11.2	9.3	8.0	7.0	6.3
400		93.0	35.3	22.0	16.1	12.8	10.6	9.1	8.0	7.2
50	800	13.3	5.0	3.1	2.3	1.8	1.6	1.3	1.1	1.0
100		26.5	10.1	6.3	4.6	3.6	3.0	2.6	2.3	2.0
150		39.8	15.1	9.4	6.9	5.4	4.5	3.9	3.4	3.0
200		53.1	20.1	12.5	9.2	7.2	6.0	5.2	4.5	4.0
250		66.3	25.2	15.7	11.4	9.0	7.5	6.5	5.7	5.1
300		79.6	30.2	18.9	13.7	10.9	9.0	7.7	6.8	6.1
350		92.9	35.2	21.9	16.0	12.7	10.5	9.0	7.9	7.1
400		106.1	40.3	25.1	18.3	14.5	12.0	10.3	9.1	8.1
50	900	14.9	5.7	3.5	2.6	2.0	1.7	1.4	1.3	1.1
100		29.8	11.3	7.0	5.1	4.1	3.4	2.9	2.5	2.3
150		44.7	17.0	10.5	7.7	6.1	5.0	4.3	3.8	3.4
200		59.7	22.6	14.1	10.3	8.1	6.7	5.8	5.1	4.5
250		74.6	28.3	17.6	12.8	10.1	8.4	7.2	6.3	5.6
300		89.5	33.9	21.1	15.4	12.2	10.1	8.6	7.6	6.8
350		104.4	39.6	24.6	17.9	14.2	11.8	10.1	8.8	7.9
400		119.3	45.2	28.1	20.5	16.2	13.4	11.5	10.1	9.0

[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the number of atmospheres.

This WHITNEY CHAIN Speed-Reducer gives Longer Life at Lower Cost...

in BRIDGEPORT PUMPING UNITS



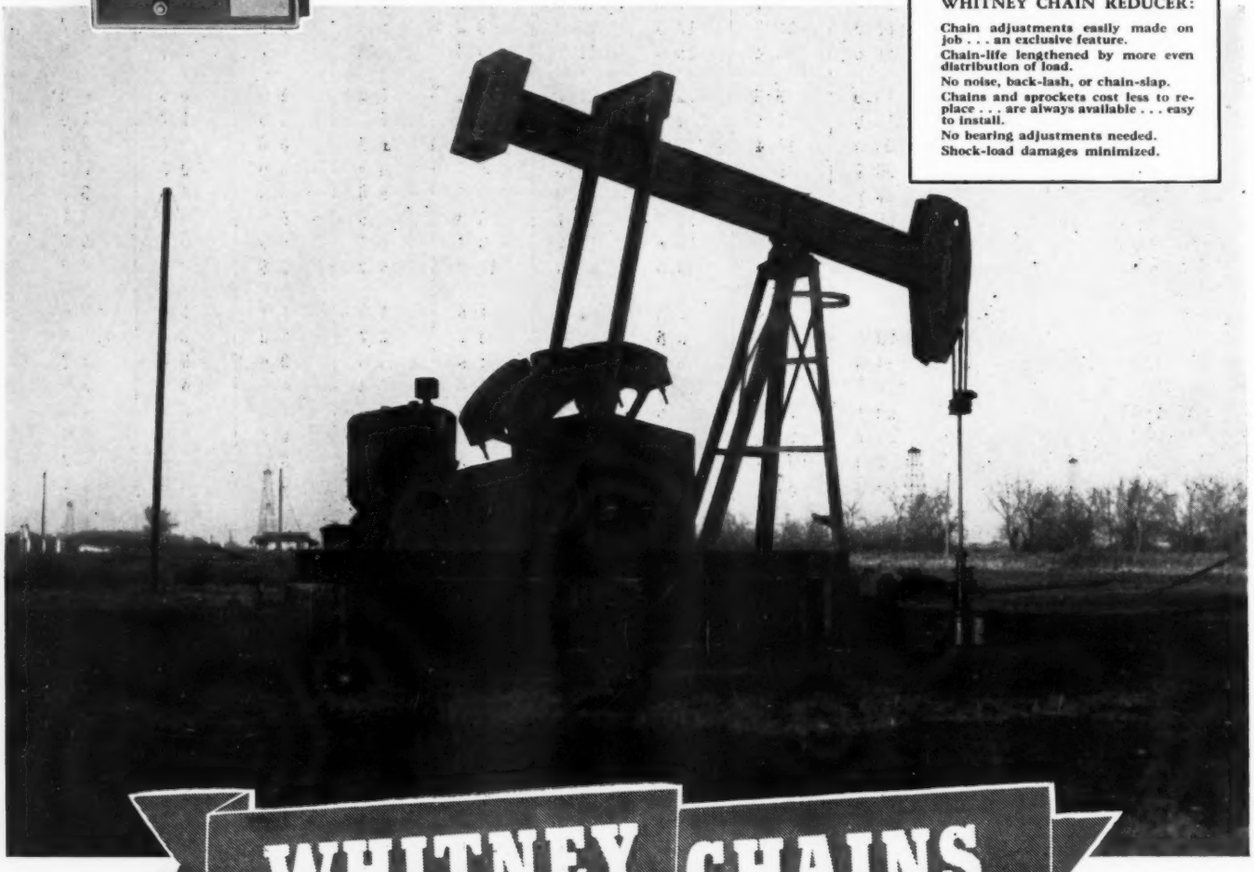
Steadily on the job, year after year, without any replacements or down-time . . . this is the kind of service that operators have learned to expect from the pumping units of the Bridgeport Machine Company, Wichita, Kansas. Built to A. P. I. specifications, these units are practical on slow payout properties and light producers, also on deep wells and large producers. And from a wide range of combinations, it is easy to obtain . . . for almost any pumping conditions . . . a Bridgeport Unit with a structure of the proper size and strength, and a Chain Reducer of the right capacity.

In the design of this Chain Reducer, Whitney engineers lent a hand . . . helping to work out a double-acting unit that lowers first cost, extends the operating life of the entire pumping unit, cuts maintenance expenses. And experience shows that Whitney Chains live out their full span of service-life. Perhaps Whitney engineers can be of service to *you*, too . . . whether you're a builder or user of oil-field equipment. Just get in touch with the nearest office or representative.

THE WHITNEY CHAIN & MFG. CO., HARTFORD, CONN.

Exclusive Advantages of Bridgeport's
WHITNEY CHAIN REDUCER:

- **Chain adjustments easily made on job . . . an exclusive feature.**
- **Chain-life lengthened by more even distribution of load.**
- **No noise, back-lash, or chain-slap.**
- **Chains and sprockets cost less to replace . . . are always available . . . easy to install.**
- **No bearing adjustments needed.**
- **Shock-load damages minimized.**



WHITNEY CHAINS

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Brance-Krachy Co. Inc., 4411 Navigation Blvd., Houston, Texas
Gulf States Tractor & Equipment Co., 222 No. Market St., Shreveport, La.
Weiss Chain & Transmission Co., 224 East Third St., Tulsa, Oklahoma
A. D. Guggenheim Co., 227 West 7th St., Amarillo, Texas
Warford Distributing Co., 319 So. Topeka Ave., Wichita, Kansas
Prager, Inc., 472 Howard Ave., New Orleans, La.
Oil Field Ignition Parts Co., 325 N. W. Second St., Okla. City, Okla.

Mid-Continent Branch Office
The Whitney Chain & Mfg. Co.
902 Allen Bldg.
Dallas
Texas

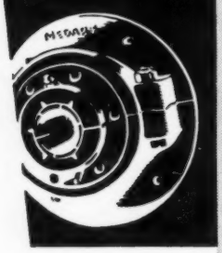
West Coast
Engineering Products Co.
747 Warehouse St.
Los Angeles
California

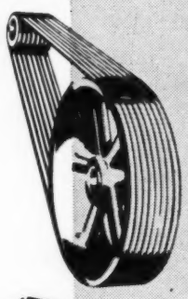
CORRELATION INDEX[1(a)] (C. I.) VALUES IN CRUDE-OIL ANALYSES[2]

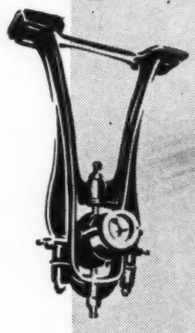
Specific gravity, G, of fraction at 60°F/60°F	Fraction no.[3]	Constant for fraction[4]	Temperature limits of fraction, °C.	Average volumetric boiling point[5] of fraction, °K	Correlation index (C. I.) values — Specific gravity—third decimal place									
					0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.790	5	336.4	125–150	404	38.	38.	39.	39.	40.	40.	41.	41.	42.	42.
.790	6	343.2	150–175	428	31.	32.	32.	32.	33.	33.	34.	34.	35.	35.
.790	7	394.4	175–200	453	25.	25.	26.	26.	27.	27.	28.	28.	29.	29.
.790	8	355.0	200–225	478	19.	20.	20.	21.	21.	22.	22.	23.	23.	24.
0.790	9	360.3	225–250	504	14.	14.	15.	15.	16.	16.	17.	17.	18.	18.
.790	10	365.0	250–275	530	9.2	9.7	10.	11.	11.	12.	12.	13.	13.	14.
.790	11	369.0	To 200[6]	554[7]	5.2	5.7	6.2	6.6	7.1	7.6	8.1	8.5	9.0	9.5
.790	12	372.8	200–225	579	1.4	1.9	2.4	2.8	3.3	3.8	4.3	4.7	5.2	5.7
.790	13	376.1	225–250	603	.....	.....	.....	.....	.....	0.5	1.0	1.4	1.9	2.4
0.800	5				43.	43.	43.	44.	44.	45.	45.	46.	46.	47.
.800	6				36.	36.	37.	37.	38.	38.	39.	39.	40.	40.
.800	7				30.	30.	31.	31.	32.	32.	32.	33.	33.	34.
.800	8				24.	24.	25.	25.	26.	26.	27.	27.	28.	28.
.800	9				19.	19.	20.	20.	21.	21.	22.	22.	22.	23.
0.800	10				14.	14.	15.	15.	16.	16.	17.	17.	18.	18.
.800	11				10.	10.	11.	11.	12.	12.	13.	13.	14.	14.
.800	12				6.2	6.6	7.1	7.6	8.1	8.5	9.0	9.5	9.9	10.4
.800	13				2.9	3.3	3.8	4.3	4.8	5.2	5.7	6.2	6.6	7.1
.800	14	379.3	250–275	628	.....	0.1	0.6	1.1	1.6	2.0	2.5	3.0	3.4	3.9
.800	15	382.3	275–300	653	.....	.....	.....	.....	.....	.....	.....	.....	0.4	0.9
0.810	6				41.	41.	41.	42.	42.	43.	43.	44.	44.	45.
.810	7				34.	35.	35.	36.	36.	37.	37.	38.	38.	39.
.810	8				29.	29.	30.	30.	31.	31.	32.	32.	33.	33.
.810	9				23.	24.	24.	25.	25.	26.	26.	27.	27.	28.
.810	10				19.	19.	20.	20.	21.	21.	22.	22.	23.	23.
0.810	11				15.	15.	16.	16.	17.	17.	18.	18.	19.	19.
.810	12				11.	11.	12.	12.	13.	13.	14.	14.	15.	15.
.810	13				7.6	8.1	8.5	9.0	9.5	10.0	10.4	10.9	11.4	11.9
.810	14				4.4	4.9	5.3	5.8	6.3	6.8	7.2	7.7	8.2	8.7
.810	15				1.4	1.9	2.3	2.8	3.3	3.8	4.2	4.7	5.2	5.7
0.820	6				45.	46.	46.	47.	47.	48.	48.	49.	49.	50.
.820	7				39.	40.	40.	41.	41.	41.	42.	42.	43.	43.
.820	8				33.	34.	34.	35.	35.	36.	36.	37.	37.	38.
.820	9				28.	29.	29.	30.	30.	31.	31.	31.	32.	32.
.820	10				23.	24.	24.	25.	25.	26.	26.	27.	27.	28.
0.820	11				19.	20.	20.	21.	21.	22.	22.	23.	23.	24.
.820	12				16.	16.	17.	17.	18.	18.	19.	19.	19.	20.
.820	13				12.	13.	13.	14.	14.	15.	15.	16.	16.	17.
.820	14				9.1	9.6	10.	11.	11.	11.	12.	12.	13.	13.
.820	15				6.1	6.6	7.1	7.6	8.0	8.5	9.0	9.4	9.9	10.
0.830	6				50.	50.	51.	51.	52.	52.	53.	53.	54.	54.
.830	7				44.	44.	45.	45.	46.	46.	47.	47.	48.	48.
.830	8				38.	39.	39.	40.	40.	41.	41.	42.	42.	42.
.830	9				33.	33.	34.	34.	35.	35.	36.	36.	37.	37.
.830	10				28.	29.	29.	30.	30.	31.	31.	32.	32.	32.
0.830	11				24.	25.	25.	26.	26.	27.	27.	28.	28.	28.
.830	12				20.	21.	21.	22.	22.	23.	23.	24.	24.	25.
.830	13				17.	18.	18.	19.	19.	19.	20.	20.	21.	21.
.830	14				14.	14.	15.	15.	16.	16.	17.	17.	18.	18.
.830	15				11.	11.	12.	12.	13.	13.	14.	14.	15.	15.
0.840	7				49.	49.	50.	50.	50.	51.	51.	52.	52.	53.
.840	8				43.	43.	44.	44.	45.	45.	46.	46.	47.	47.
.840	9				38.	38.	39.	39.	40.	40.	41.	41.	41.	42.
.840	10				33.	33.	34.	34.	35.	35.	36.	36.	37.	37.
0.840	11				29.	29.	30.	30.	31.	31.	32.	32.	33.	33.
.840	12				25.	26.	26.	27.	27.	28.	28.	28.	29.	29.
.840	13				22.	22.	23.	23.	24.	24.	25.	25.	26.	26.
.840	14				19.	19.	20.	20.	21.	21.	22.	22.	22.	23.
.840	15				16.	16.	17.	17.	18.	18.	19.	19.	19.	20.
0.850	7				53.	54.	54.	55.	55.	56.	56.	57.	57.	58.
.850	8				48.	48.	49.	49.	50.	50.	51.	51.	51.	52.
.850	9				42.	43.	43.	44.	44.	45.	45.	46.	46.	47.
.850	10				38.	38.	39.	39.	40.	40.	41.	41.	41.	42.
0.850	11				34.	34.	35.	35.	36.	36.	37.	37.	37.	38.
.850	12				30.	30.	31.	31.	32.	32.	33.	33.	34.	34.
.850	13				27.	27.	28.	28.	28.	29.	29.	30.	30.	31.
.850	14				23.	24.	24.	25.	25.	26.	26.	27.	27.	28.
.850	15				20.	21.	21.	22.	22.	23.	23.	24.	24.	25.

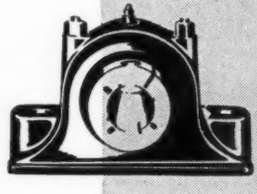
(a) For explanatory notes see sheet 1, P 721.02.

Use *More* of Your Present Power Capacity for *Actual* Work









Useful Power is Applied Power . . . not power at its source. Today's demands for increased production involve the necessity for more *applied* power. There are two ways in which this may be obtained . . . either by increasing the capacity of the source of power—difficult to do in a limited time—or, get more *useful* power from your present source.

MEDART offers the solution to your problem of obtaining a maximum of applied or useful power. MEDART Transmission Equipment minimizes loss through friction . . . eliminates many other wasteful practices of improperly transmitted mechanical power . . . inefficiencies which drain power at every turn of the wheel.

MEDART engineers will cooperate with you in the analysis of your drives. Let them point out how you can get more *applied* power from your power source.

MEDART OFFERS A SINGLE RESPONSIBILITY FOR DRIVE ECONOMY

One name, MEDART, protects you when you standardize on MEDART Power Transmission Equipment. Your buying is simplified and the successful operation of your drives is assured when you specify MEDART on your requisitions and purchase orders . . . Write for latest catalogs.

For "Power-Travel" at Reduced Rates

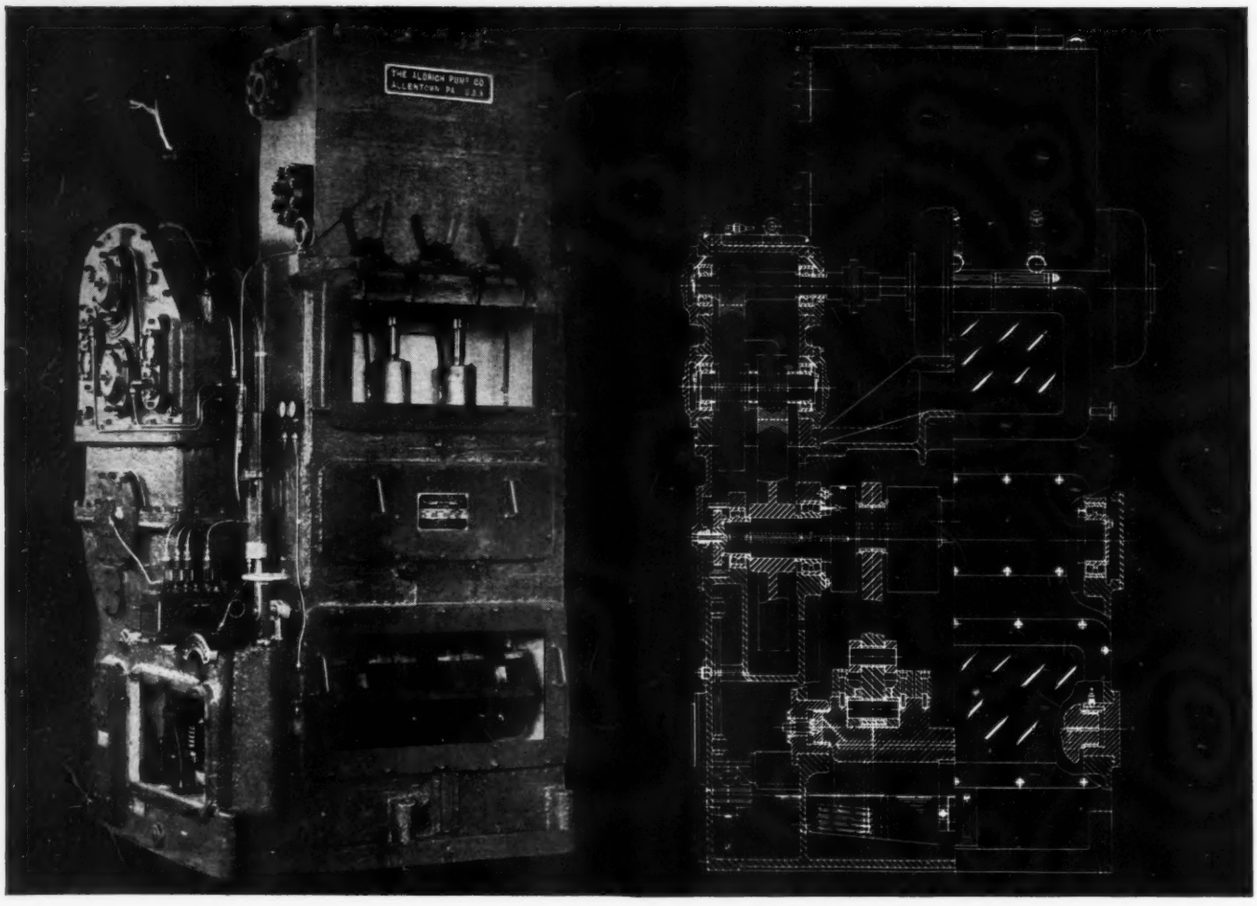
MEDART

THE MEDART COMPANY
3514 DeKalb St. • St. Louis, Mo.

VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 1½-IN. AND 3½-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	1000	12.8	4.8	3.0	2.2	1.7	1.4	1.2	1.1	0.9
100		25.7	9.5	5.9	4.3	2.4	2.8	2.4	2.3	1.9
150		38.5	14.3	8.9	6.5	5.1	4.2	3.6	3.4	2.8
200		51.3	19.1	11.8	8.6	6.8	5.6	4.8	4.6	3.8
250		64.1	23.8	14.8	10.8	8.5	7.1	6.0	5.7	4.7
300		77.0	28.6	17.8	12.9	10.2	8.5	7.2	6.9	5.7
350		89.8	33.4	20.7	15.1	11.9	9.9	8.5	8.0	6.6
400		102.6	38.1	23.7	17.3	13.6	11.3	9.7	9.1	7.6
50	1250	15.7	5.9	4.0	2.7	2.1	1.7	1.5	1.4	1.2
100		31.4	11.9	8.0	5.4	4.2	3.5	3.0	2.8	2.3
150		47.2	17.8	12.1	8.0	6.3	5.2	4.5	4.2	3.5
200		62.9	23.8	16.1	10.7	8.4	7.0	6.0	5.6	4.7
250		78.6	29.7	20.1	13.4	10.6	8.7	7.5	7.1	5.8
300		94.3	35.6	24.1	16.1	12.7	10.5	9.0	8.5	7.0
350		110.1	41.6	28.1	18.7	14.8	12.2	10.5	9.9	8.1
400		125.8	47.5	32.1	21.4	16.9	14.0	12.0	11.3	9.3
50	1500	19.0	7.1	4.4	3.2	2.5	2.1	1.8	1.6	1.4
100		37.9	14.2	8.8	6.4	5.0	4.2	3.6	3.1	2.8
150		56.9	21.3	13.2	9.6	7.6	6.3	5.3	4.7	4.1
200		75.9	28.5	17.6	12.8	10.1	8.3	7.1	6.2	5.5
250		94.8	35.6	22.0	16.0	12.6	10.4	8.9	7.8	6.9
300		113.8	42.7	26.4	19.2	15.1	12.5	10.7	9.3	8.3
350		132.7	49.8	30.8	22.4	17.6	14.6	12.4	10.9	9.7
400		151.7	56.9	35.2	25.6	20.2	16.7	14.2	12.4	11.0
50	1750	22.0	8.3	5.1	3.7	2.9	2.4	2.1	1.9	1.6
100		44.0	16.6	10.3	7.4	5.9	4.8	4.1	3.9	3.2
150		65.9	24.9	15.4	11.2	8.8	7.3	6.2	5.8	4.8
200		87.9	33.2	20.5	14.9	11.7	9.7	8.3	7.8	6.4
250		109.9	41.4	25.6	18.6	14.6	12.1	10.3	9.7	8.0
300		131.9	49.7	30.8	22.3	17.6	14.5	12.4	11.7	9.6
350		153.9	58.0	35.9	26.1	20.5	16.9	14.4	13.6	11.2
400		175.9	66.3	41.0	29.8	23.4	19.3	16.5	15.6	12.8
50	2000	25.1	9.5	5.9	4.2	3.3	2.8	2.3	2.1	1.8
100		50.2	18.9	11.7	8.5	6.7	5.5	4.7	4.2	3.6
150		75.3	28.4	17.6	12.7	10.0	8.3	7.0	6.3	5.5
200		100.5	37.8	23.4	17.0	13.3	11.0	9.4	8.4	7.3
250		125.6	47.3	29.3	21.2	16.7	13.8	11.7	10.5	9.1
300		150.7	56.8	35.1	25.5	20.0	16.5	14.1	12.6	10.9
350		175.8	66.2	41.0	29.7	23.4	19.3	16.4	14.6	12.7
400		200.9	75.7	46.8	33.9	26.7	22.0	18.8	16.7	14.5
50	2250	28.2	10.6	6.6	4.8	3.7	3.1	2.6	2.5	2.0
100		56.5	21.3	13.1	9.5	7.5	6.2	5.3	5.0	4.1
150		84.7	31.9	19.7	14.3	11.2	9.3	7.9	7.5	6.1
200		113.0	42.5	26.3	19.1	15.0	12.4	10.5	9.9	8.1
250		141.2	53.2	32.9	23.8	18.7	15.4	13.2	12.4	10.2
300		169.5	63.8	39.4	28.6	22.5	18.5	15.8	14.9	12.2
350		197.7	74.5	46.0	33.4	26.2	21.6	18.4	17.4	14.3
400		226.0	85.1	52.6	38.1	30.0	24.7	21.0	19.9	16.3
50	2500	31.4	11.8	7.3	5.3	4.2	3.4	2.9	2.8	2.3
100		62.7	23.6	14.6	10.6	8.3	6.8	5.8	5.5	4.5
150		94.1	35.4	21.9	15.9	12.5	10.3	8.7	8.3	6.8
200		125.5	47.2	29.2	21.2	16.6	13.7	11.7	11.0	9.0
250		156.9	59.0	36.5	26.4	20.8	17.1	14.6	13.8	11.3
300		188.2	70.9	43.8	31.7	24.9	20.5	17.5	16.5	13.5
350		219.6	82.7	51.1	37.0	29.1	24.0	20.4	19.3	15.8
400		251.0	94.5	58.4	42.3	33.2	27.4	23.3	22.0	18.0

[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the number of atmospheres.



Aldrich-Groff Controllable Capacity Pump, of the constant speed triplex type, built by The Aldrich Pump Company for charging butane against 1,400-PSI in a catalytic polymerization plant of a large Canadian oil refinery.

ALWAYS TOGETHER

ALDRICH-GROFF PUMPS AND SKF BEARINGS

For years SKF Bearings have performed satisfactorily on pumps. So it was only natural that Aldrich engineers, in developing this variable delivery pump, selected SKF Spherical Bearings for the crankshaft and drive gears of their pumps. They know that SKF Spherical Bearings have self-aligning characteristics which compensate for shaft deflection, distortion or weave without bearing binding or losing bearing capacity . . . that SKFs require no fussy adjustments—are always on the job. Where bearing performance is a requisite, SKFs are always a part of the job. 4791

SKF INDUSTRIES, INC., PHILADELPHIA, PA.

VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 1¼-IN. AND 3½-IN. TUBING

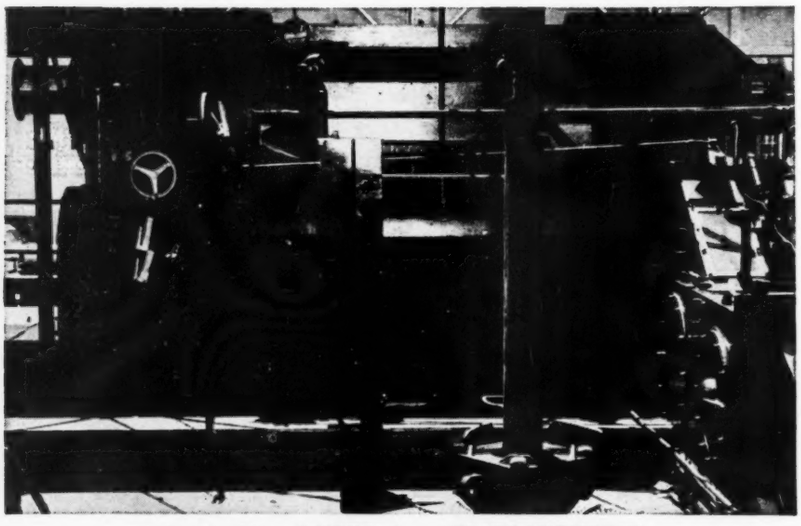
Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	1000	11.7	4.3	2.7	2.0	1.5	1.3	1.1	1.0	0.9
100		23.3	8.7	5.4	3.9	3.1	2.6	2.2	2.1	1.7
150		35.0	13.0	8.1	5.9	4.6	3.8	3.3	3.1	2.6
200		46.6	17.3	10.8	7.8	6.2	5.1	4.4	4.2	3.4
250		58.3	21.6	13.4	9.8	7.7	6.4	5.5	5.2	4.3
300		69.9	26.0	16.1	11.8	9.3	7.7	6.6	6.2	5.1
350		81.6	30.3	18.8	13.7	10.8	9.0	7.7	7.3	6.0
400		93.2	34.6	21.5	15.7	12.4	10.3	8.8	8.3	6.9
50	1250	14.3	5.4	3.6	2.4	1.9	1.6	1.4	1.3	1.1
100		28.6	10.8	7.3	4.9	3.8	3.2	2.7	2.6	2.1
150		42.9	16.2	10.9	7.3	5.8	4.7	4.1	3.8	3.2
200		57.1	21.6	14.6	9.7	7.7	6.3	5.4	5.1	4.2
250		71.4	27.0	18.2	12.2	9.6	7.9	6.8	6.4	5.3
300		85.7	32.4	21.9	14.6	11.5	9.5	8.1	7.7	6.3
350		100.0	37.8	25.5	17.0	13.4	11.1	9.5	9.0	7.4
400		114.3	43.2	29.2	19.5	15.4	12.7	10.9	10.3	8.5
50	1500	17.2	6.3	4.0	2.9	2.3	1.9	1.6	1.4	1.3
100		34.5	12.7	8.0	5.8	4.6	3.8	3.2	2.8	2.5
150		51.7	19.0	12.0	8.7	6.9	5.7	4.8	4.2	3.8
200		68.9	25.4	16.0	11.6	9.2	7.6	6.5	5.7	5.0
250		86.1	31.7	20.0	14.5	11.4	9.5	8.1	7.1	6.3
300		103.4	38.1	24.0	17.4	13.7	11.4	9.7	8.5	7.5
350		120.6	44.4	28.0	20.4	16.0	13.3	11.3	9.9	8.8
400		137.8	50.8	32.0	23.3	18.3	15.1	12.9	11.3	10.0
50	1750	20.0	7.5	4.7	3.4	2.7	2.2	1.9	1.8	1.5
100		39.9	15.1	9.3	6.8	5.3	4.4	3.7	3.5	2.9
150		59.9	22.6	14.0	10.1	8.0	6.6	5.6	5.3	4.6
200		79.9	30.1	18.6	13.5	10.6	8.8	7.5	7.1	5.8
250		100.0	37.7	23.3	16.9	13.3	11.0	9.4	8.9	7.3
300		119.8	45.2	28.0	20.3	16.0	13.2	11.2	10.6	8.7
350		139.8	52.7	32.6	23.7	18.6	15.4	13.1	12.4	10.2
400		159.8	60.2	37.3	27.1	21.3	17.6	15.0	14.2	11.6
50	2000	22.8	8.6	5.3	3.9	3.0	2.5	2.1	1.9	1.7
100		45.6	17.2	10.6	7.7	6.1	5.0	4.3	3.8	3.3
150		68.4	25.8	15.9	11.6	9.1	7.5	6.4	5.7	5.0
200		91.3	34.4	21.3	15.4	12.1	10.0	8.5	7.6	6.6
250		114.1	43.0	26.6	19.3	15.2	12.5	10.7	9.5	8.3
300		136.9	51.6	31.9	23.1	18.2	15.0	12.8	11.4	9.9
350		159.7	60.2	37.2	27.0	21.2	17.5	14.9	13.3	11.6
400		182.5	68.8	42.5	30.8	24.3	20.0	17.1	15.2	13.2
50	2250	25.7	9.7	6.0	4.3	3.4	2.8	2.4	2.3	1.8
100		51.3	19.3	11.9	8.7	6.8	5.6	4.8	4.5	3.7
150		77.0	29.0	17.9	13.0	10.2	8.4	7.2	6.8	5.5
200		102.6	38.7	23.9	17.3	13.6	11.2	9.6	9.0	7.4
250		128.3	48.3	29.9	21.6	17.0	14.0	12.0	11.3	9.2
300		154.0	58.0	35.8	26.0	20.4	16.8	14.3	13.5	11.1
350		179.6	67.6	41.8	30.3	23.8	19.6	16.7	15.8	12.9
400		205.3	77.3	47.8	34.6	27.2	22.5	19.1	18.1	14.8
50	2500	28.5	10.7	6.6	4.8	3.8	3.1	2.6	2.5	2.0
100		57.0	21.5	13.3	9.6	7.5	6.2	5.3	5.0	4.1
150		85.5	32.2	19.9	14.4	11.3	9.3	7.9	7.5	6.1
200		114.0	42.9	26.5	19.2	15.1	12.4	10.6	10.0	8.2
250		142.5	53.6	33.1	24.0	18.9	15.6	13.2	12.5	10.2
300		171.0	64.4	39.8	28.8	22.6	18.7	15.9	15.0	12.3
350		199.5	75.1	46.4	33.6	26.4	21.8	18.5	17.5	14.3
400		228.0	85.8	53.0	38.4	30.2	24.9	21.2	20.0	16.4

[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the number of atmospheres.

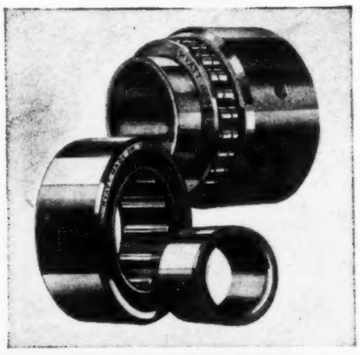
ORDER OF THE DAY

UP IN THE FRONT LINE of machine design . . . guarding gears, wheels, shafts, and profits from the onslaught of friction and wear . . . millions of Hyatt Roller Bearings carry on their unremitting war against inefficiency.

Serving and saving, year after year, Hyatts carry on through long hours, adverse weather conditions, extreme speeds and shock loads. They have the staying power to keep equipment going, to prolong machine life. Make Hyatt Equipped your "order of the day." Hyatt Bearings Division, General Motors Sales Corporation, Harrison, New Jersey; Chicago, Detroit, Pittsburgh, San Francisco.



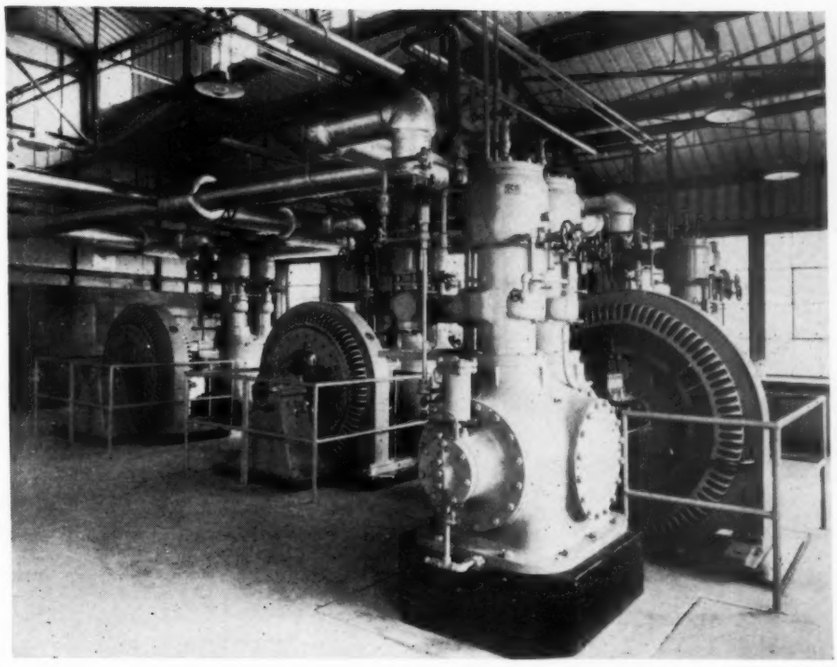
In the New EMSCO Type ED DRAWWORKS all shaft bearings are Hyatts.



HYATT

ROLLER BEARINGS

QUIET



Refrigeration plant for Stratford acid-treating process, Wilshire Oil Corporation refinery, Santa Fe Springs, California

Refrigeration in the Petroleum Industry

by

T. H. Eakle, Jr.

Assistant Manager, Industrial Refrigeration Division, York Ice Machinery Corporation

☆ Cold-producing equipment now is vital part of nearly every modern refining process

TEMPERATURE, defined as "the measure of heat," according to Webster, is a commonplace word to most, with less meaning than "hot" or "cold," unless amplified by the degree of temperature on a familiar thermometer scale.

"Temperature" in the broad sense cannot be thus lightly discarded. Without the ability to produce, measure, and accurately control temperatures, our entire life, surroundings, and the world itself would be vastly different. This human control over temperature is generally divided into high and low temperatures. Or, in the more commonly used designations of "hot" and "cold."

High temperatures have been produced, measured, and controlled with increasing accuracy since man first discovered his ability to build a fire. Now, wood, coal, oil, gas, and the sun rays themselves are used in the production of heat and other heating mediums—electricity, hot water, steam.

Low temperatures have not been under the control of man for so long a period, but cooling, chilling, and freezing have been gradually taken out of the class of natural phenomena so that now the artificial production of refrigeration is a well-founded science.

High- and low-temperature production and application are of utmost importance to the processing industry. "Temperature" is most certainly the "life blood of the industry" if any one tool or agency can be given this title.

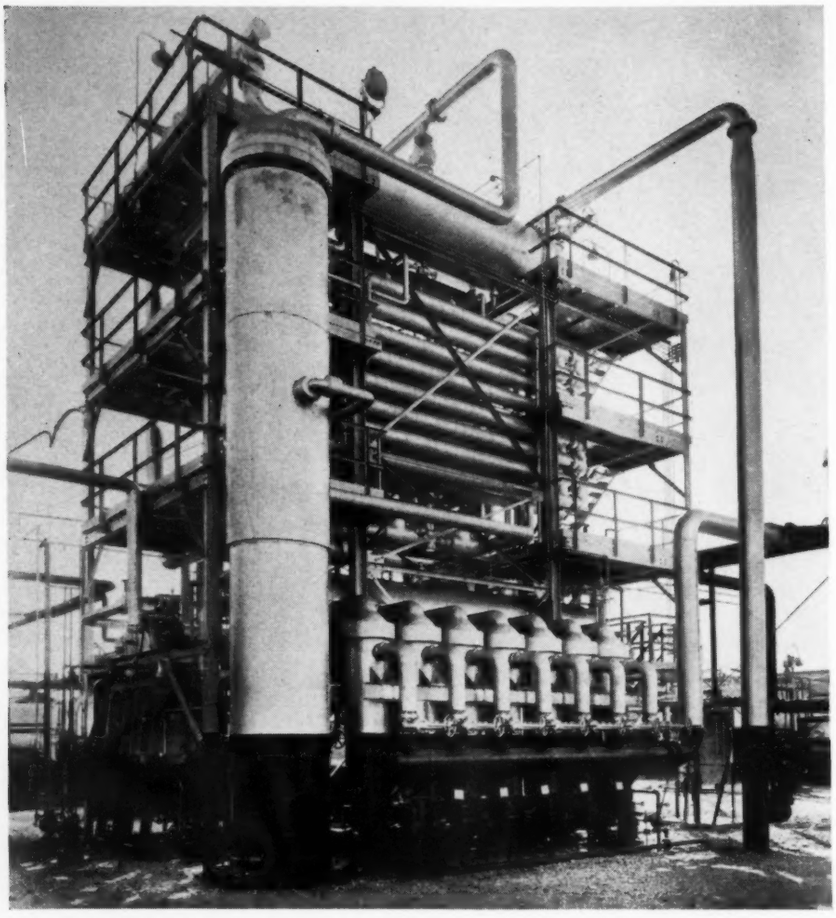
Oil Refinery

"Temperature," the processing tool of the oil refinery, as used in the early history of the industry had only one significance—high temperature. Heat was applied in various parts of the cycle to breakdown the crude oil into its component parts—lubricating oil, kerosine, and gasoline. These products would gradually cool down to surrounding temperatures as they were held in storage. Thus, the air was the cooling medium.

The lubricating oil produced was used to compound axle greases, steam

T. H. EAKLE, JR.

received a B.S. degree in mechanical engineering from Pennsylvania State College in 1935—Was employed by the Landis Machine Company, Waynesboro, Pennsylvania, and later accepted a position with the York Ice Machinery Corporation, York, Pennsylvania—As special estimator for the Industrial Refrigeration Division he specialized in the requirements and application of refrigeration equipment to many types of industrial processes, and has been an instructor in the York Sales Engineering training course conducted each year by the company—Recently appointed assistant manager of the Industrial Refrigeration Division, he is now actively engaged in studying the refrigeration requirements of new industries as they develop and methods of improving the application of refrigeration to established industries.



A 700-ton ammonia absorption refrigeration system of the outdoor type applied to an oil refinery

cylinder lubricants, and lubricants for similar applications. The cold weather of mid-winter caused the oil to stiffen in engines used outdoors, resulting in wear due to lack of lubrication and requiring an excessive amount of power to operate. The logical solution was to refine the oil further to remove the ingredients that caused the stiffening action.

Wax was found to be the offender. Various means were devised for its removal involving settling, filtering, and cooling to as low a temperature as possible with available well water.

This satisfied the requirements for a few years. But soon, new high-speed precision engines in automobiles, airplanes, and countless other applications were requiring a better refined lubricating oil with less wax and other gummy substances. Still more filters were added to the petroleum processing cycle. More well water was used. Cost of production increased but the wax content still exceeded desirable limits.

Low temperatures answered the problem. Refrigeration, by chilling the oil to lower temperatures than will ever be encountered in nature, amplified the previous treatment and the wax is now removed economically, rapidly, and under accurate control so that the same results are obtained winter or summer.

The process is, of course, highly complicated, several excellent cycles being available for use with oil of any characteristic. Basically, however, the use of refrigeration is necessary to all these, requiring the chilling of a mixture of oil and solvent with a mechanism that continuously scrapes the accumulating wax from the heat transfer surface.

Dewaxing is just one of many processes using refrigeration in the refining of oil. Sulphur is removed from gasoline to give a better product. Here an acid reaction with the gasoline removes the sulphur but in doing so generates heat that must be removed as it forms in order for the process to take place. Low temperature again supplies the answer by refrigerant evaporation in small tubes directly surrounded by the solution of acid and gasoline.

The huge Port Arthur, Texas, plant of the Gulf Refining Company uses 350 tons of refrigeration in removing the sulphur from 12,000 bbl. of gasoline per day, using an ammonia compression system.

New refining processes requiring refrigeration are being developed daily. Alkylation, one of the most recently developed processes, permits recovery of high octane gasolines from what were once refinery waste gases. Shell Oil Company, Inc., has just installed the newest plant of this type at Deer Park, Texas. It includes a 700-ton refrigeration ammonia absorption system of a new and efficient design. This plant is a complete outdoor installation devoid of any building to enclose the mechanism from the elements.

Conservation of natural resources in gas distillate fields has contributed a new step in the oil refinery cycle in recent years and again refrigeration plays its part. This new branch of the industry revolves about what is known as a recycling plant. Here refrigeration is used in the recovery of condensate from gas distillate wells, after which the gas is pumped back to the well. Heretofore the general practice for condensate recovery from such gas distillate wells was to drop the pressure from the wellhead pressure and either waste the gas or, in those cases where there was a market, sell it. The recovery of condensate depended entirely on the drop in pressure. The result of such operation was a continually decreasing recovery, as many of the condensables dropped out in the well as the well pressure was reduced. The condensate so lost is not recoverable.

Conservation laws are preventing such operation, and production from these wells has been limited to those cases where there is a market for the gas. In the recycling plant the gas from a distillate well is processed under high pressure, and the well pressure is maintained by returning the dry gas to the well after processing. Refrigeration requirements vary depending upon the initial gas pressure, the pressure under which the processing is carried out, the drop in gas pressure permitted during processing, and other factors.

Estimation of Underground Reserves of Petroleum[1]

☆ Detailed analysis of reservoir includes correlation of well data employing mathematical principles of treating statistical information

PART I

by B. B. Bilibin

Classifying Oil-Bearing Areas

BEFORE attempting a detailed calculation of the oil reserves in a given region, the area under consideration should be subdivided on the basis of its oil potentialities into the following six major classifications, which in turn should be blocked in color on the regional map of the district.

(1) Oil-producing areas, classified as (a) areas containing only 1 oil-producing formation, (b) areas in which there are 2 to 5, and (c) areas in which there are more than 5 distinct oil-producing horizons.

(2) Areas in which drilling has proved the existence of commercially productive oil-bearing formations but which have not been fully developed by wells or their areal extents determined. Areas falling under (2) should be segregated further as to the number of oil-bearing formations as listed under (1).

(3) Areas which, as a result of geological and geophysical investigations and prospecting, are considered likely to contain commercially productive oil-bearing formations.

(4) Areas in which surface geology indicates the existence of favorable structures but which have not been sufficiently explored by prospecting to warrant classifying them as oil bearing.

(5) Areas that might contain oil-bearing formations but for which there is no positive evidence for or against their oil-bearing potentialities.

(6) Areas that geological studies indicate, or deep drilling has proved, do not contain oil-bearing sands and rocks.

To show the different areas on the district map so that they will stand out clearly, the following color scheme is suggested:

Group (1), red, shading from light to dark depending upon the number of oil-producing formations; group (2), brown, shading from light to dark to show the number of oil-bearing formations; a gray color for group (3) areas; yellow for group (4); black diagonal shading for group (5), and the areas included in the sixth group might best be left uncolored.

Although only the first four groups are of interest when calculating the oil reserves in a given district, it is helpful in any reserve study to prepare a table in which are grouped, as suggested in Table 1, the number of acres in each group area and the percentage that area is of the total area of the district under investigation.

[1]Translated from the Russian Geological Journal, *Problemy Sovetskoi Geologii* (Problems of Soviet Geology) 6, 1936, pp. 34-43, 133-196, by A. A. Boehtlingk, publisher of *Foreign Petroleum Technology*, Berkeley, California.

TABLE I

Suggested table for recording acreage of classified areas

Group	Area in acres	Percentage of total
1. Oil-producing areas		
a. One oil-producing formation		
b. Two to 5 oil-producing formations		
c. Six or more oil-producing formations		
2. Areas proved to contain undeveloped oil-bearing formations		
a. One oil-bearing formation		
b. Two to 5 oil-bearing formations		
c. Six or more oil-bearing formations		
3. Areas probably (based on geological and geophysical data) containing oil-bearing formations		
4. Areas likely (based on geological reconnaissance) to contain oil-bearing formations		
5. Areas whose oil-bearing possibilities are uncertain		
6. Areas positively not oil bearing		
		100

Types of Oil Reserves

In order to facilitate the calculation of underground reserves in areas proved by drilling to contain commercially productive oil-bearing formations, and in areas where prospecting has indicated the existence of oil in commercial quantities, oil reserves should be classified as follows:

1. Proved reserves . . . . class A_1
2. Semi-proved reserves . . class A_2
3. Probable (tentative) reserves . . . . . class B
4. Possible (anticipated) reserves . . . . . class C_1
5. Prospective reserves . . class C_2

In the above classification of reserves it is assumed that:

(1) Proved reserves (A_1) represent oil that remains to be recovered by wells in a producing field,

(2) Semi-proved reserves (A_2) represent oil that will be recovered by wells to be drilled within the established boundaries of an explored formation,

(3) Probable reserves (B) represent oil that will be recovered from areas beyond the boundaries of tested formations, or from already discovered but insufficiently explored horizons,

(4) Possible reserves (C_1) represent oil that may be recovered from areas in which geological or geophysical studies have determined the existence of structures favorable for the accumulation of oil and prospecting has shown that they contain oil in commercial quantities.

(5) Prospective reserves (C_2) represent oil that may be obtained from areas that prospecting has proved contain oil and the existence of commercially productive forma-

tions is assumed. The symbol C_2 also represents oil that may be obtained from favorable geological structures but in which the presence of oil has not been proved conclusively by drilling.

Proved, semi-proved, probable, and possible reserves may be further classified as to their source areas into groups as follows:

(1) Areas being exploited by wells (basis: single oil-producing horizon):

Oil that will be produced from the existing wells—proved reserves, A_1.

Oil that will be obtained from explored and outlined areas (except that yet to be recovered from wells in areas already producing)—semi-proved reserves, A_2. Oil that will be recovered from prospected but not yet outlined areas, or from horizons not completely explored—probable reserves, B.

(2) Areas known to contain oil in commercial quantities but which have not been outlined and are not now being exploited:

Oil that will be recovered from formations that have been tested but not outlined, or from horizons that have been investigated but not adequately explored—probable reserves, B.

Oil that will be recovered from formations that have not been tested but which appear from geological investigations to be structurally favorable for the accumulation of oil—possible reserves, C_1.

(3) Areas that may be considered, as a result of field investigations or prospecting, as capable of yielding oil:

Oil that will be obtained from formations known to contain oil and for which favorable structure has been determined by geological investigations—possible reserves, C_1.

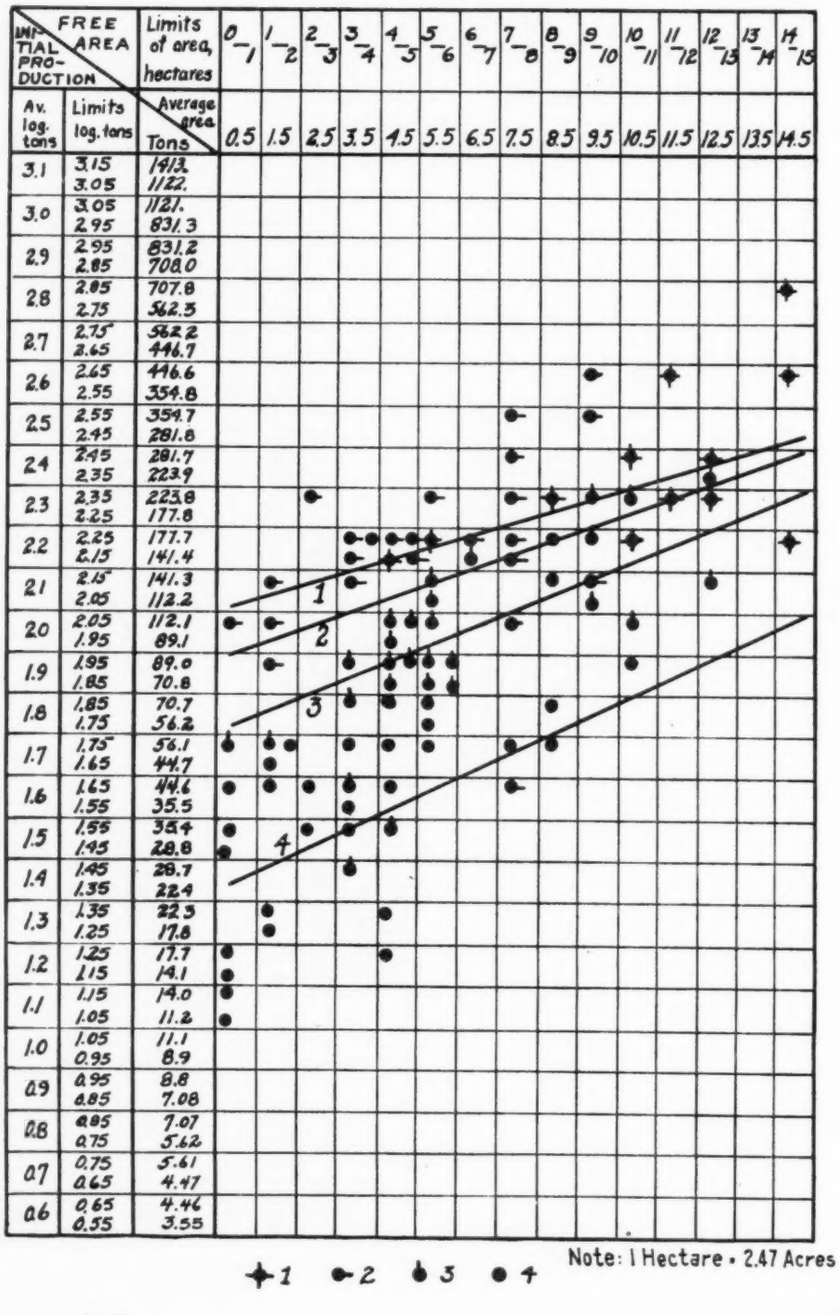
Oil that may be recovered from unknown but likely oil-bearing formations—prospective reserves, C_2.

(4) Areas in which commercial accumulations of oil have been indicated by general geological reconnaissance but which have not been tested or at least have not been conclusively explored by prospecting:

Oil that may be recovered from all formations in such areas—prospective reserves, C_2.

A table in which petroleum reserves are grouped as to source is given as Table 2.

Fig. 1. Correlation chart showing relationship between the initial oil-production rates of wells and their free areas segregated as to the well-months of production of adjacent wells



Estimating Reserves

The following methods are used to estimate reserves:

1. Proved (A_1) and semi-proved (A_2) reserves:

   Future yield of oil is determined by means of production-decline curves,

2. Probable (B) reserves:

   The quantity of oil to be recovered is estimated from production-decline curves based on the producing performance of wells in nearby similar oil-producing areas, or by the volumetric method,

3. Possible (C_1) and prospective (C_2) reserves are calculated by the volumetric method.

Production-Decline Curve Method

The production-decline curve method of estimating the future production of wells is based on well-performance data on individual wells or groups of wells producing oil from the

areas under consideration. Production-decline curves are established from initial (30-day) production data and the subsequent rate of decline of oil production projected into the future to the limit of the economic rate of yield. The initial yields and the rates of decline of oil production of wells depend upon the characteristics of the oil-bearing formations, the manner in which the wells are operated, the rate of field development, and the spacing of the wells. Consequently, initial yields and rates of production decline seldom are the same for all wells in a group even when the oil-producing formation is regular and uniform throughout an area.

As it may be necessary to calculate the quantity of oil remaining in a partly developed reservoir at any time during its exploitation, the initial yields of wells yet to be drilled and their rates of production decline are calculated by a special method that is based on the relationship between the initial yields of producing wells, their production-decline rates, the rate of development of the reservoir, and the natural characteristics of the oil-bearing formation. The method is known as the *Method of Curves of Dependency* and is based on actual well-production data, characteristics of the oil-bearing formations (reservoir pressure, permeability, etc.) and the field exploitation program (rate of development, spacing of wells, etc.)

Theory of Correlation of Mathematical Statistics

The theoretical basis of the theory of correlation of mathematical statistics and its workings are described in textbooks dealing with mathematics and, therefore, will not be discussed here. Furthermore, the application of the method of constructing curves of dependency and their use in calculating oil reserves already have been described in detail in a previous article by the writer[2].

As the probable initial yield of new oil wells (in a field in which some wells already have been drilled and are producing oil) is dependent upon the rate of field development and the size (area) of the surrounding undrilled (free) area about the newly drilled well, "distance-time" curves are constructed. The construction of the curves is based on charts of dependency formed from actual data on the initial yield of the producing wells (variable y); the distance between the wells, that is, the drainage (free) area assigned to the new wells at the time their drilling is begun (variable x), and the rate of production of the oil-bearing formation about the wells based on the well-months of production of the surrounding wells (variable z).

[2]"Calculating Underground Oil Reserves," by B. B. Bilibin. *ONTI*, Aznefteizdat, Baku-Moscow, 1935.

TABLE 2
Classification of petroleum reserves

Group	Class of reserve				
	A_1	A_2	B	C_1	C_2
1. Oil-producing areas	Remaining yield of wells already producing	Oil to be recovered from underlying tested formations within the boundaries of the oil-producing areas	Oil to be recovered from extensions of producing areas and from lower formations that have been discovered by drilling but have not been thoroughly explored.	Oil to be recovered from extensions and lower horizons that geological studies indicate are oil bearing	
2. Areas not being exploited but known to contain commercial oil-bearing formations			Oil to be recovered from extensions and lower formations that have been discovered but not thoroughly explored.	Oil to be recovered from extensions and lower formations as determined by cross-sections and whose oil potentialities are based on geological interpretations	
3. Areas that have been prospected and are believed to contain commercial deposits of oil				Oil to be recovered from formations shown by cross-sections and geological analogy to be favorable for oil accumulations	Oil to be recovered from all formations assumed to underly the area
4. Areas that geological reasoning indicates are likely to be oil bearing					Oil that might be recovered from all formations in these areas

In forming the basic correlation charts the following field data, which obviously vary for each well, are used for each oil-bearing horizon.

1. Initial (30-day) oil yield of the wells
2. Undrilled (free) area about the well at the beginning of drilling, based upon the distance from the new well to the surrounding producing wells
3. Well-months of production of the wells surrounding the new well at the time it is brought in.

Fig. 1 is an example of such a correlation chart. The abscissa axis represents variable x (free area) and along this axis in each of the squares at the top of the chart appear two figures representing the limits of an area. In other words, in the second square at the left, for example, appears the figure 1-2, signifying a free area from one to two hectares (2.47 to 4.94 acres) in size.

In the square immediately below the square containing the figure 1-2 appears the figure 1.5, which is the average of the limiting areas (1 to 2) shown in the square just above.

Variable y (initial oil yield of the well) occupies the column of square at the left of the chart. In the squares of the right-hand column are shown limits of initial production in metric tons, for example, 11.2 to 14, 28.2 to 35.4, etc.; in the middle column appear their corresponding logarithms, 1.05 to 1.15, 1.45 to 1.55, etc., and the figures in the column at the extreme left are the average logarithms of the corresponding logarithms shown in the middle column.

Variable z (number of well-months of production of adjacent wells) is segregated into four intervals of its value, that is, into groups representing 3 to 10, 10 to 30, 30 to 100, and 100 to 300 well-months. The logarithms of these values are used.

Variable y is divided into logarithmic intervals to keep down the size of the chart and also because the regularity of the initial yields of wells shows that the relationship between x and y is expressible by an equation of the form $y = AB^x$ or $\log y = \log A + x \log B$. Consequently, the relationship between $\log y$ and x is linear and can be represented as a straight line on a Cartesian (rectangular coördinate) chart.

Referring to the intervals of variable z, its grouping according to increments is carried out so that approximately the same number of data is in each group, which depends upon the rate of production. In constructing correlation charts for a number of oil-bearing formations it often is advisable to group variable z into equal intervals of logarithms. Such a grouping was used for variable z in Fig. 1.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer.*

Running Tour

WITH MEN IN THE INDUSTRY

J. F. WHITLEY, JR., foreman with the Rodessa Oil Refining Company, Shreveport, Louisiana, recently changed his affiliation to the Wood River oil and Refining Company. He is a foreman for that company at Hartford, Illinois.

FRANCIS J. LE BLANC, sales engineer, Sperry-Sun Well Surveying Company, formerly at Seagraves, Texas, has been called for active duty by the United States Army. He is a second lieutenant in the Engineering Corps and is stationed at Louisiana State University as assistant professor of military science and tactics.

H. E. HENSLEE, engineer-draftsman with Sinclair Prairie Oil Company at Tulsa, Oklahoma, recently joined the staff of Ford, Bacon and Davis. At present he is stationed at Texas City, Texas, engaged in the construction of the Carbide and Carbon Chemicals Corporation's $15,000,000 chemical plant.

GEORGE P. ALDEN, who has been engineer's assistant at Bunkie, Louisiana, for the Amerada Petroleum Corporation, has become affiliated as a petroleum engineer with Jo H. CABLE, consulting petroleum engineering firm at Wichita Falls, Texas.

ROY J. MILLER, consulting petroleum engineer, Chicago, Illinois, is now mechanical superintendent at Los Angeles, California, for the California Shipbuilding Corporation.

JOHN M. KENDERDINE, branch manager at Midland, Texas, for the Norvell-Wilder Supply Company, now is on active duty as first lieutenant in the office of the quartermaster general in Washington, D. C.

E. W. POTTER, who has been superintendent of refineries for Cosden Petroleum Corporation, Big Spring, Texas, is now executive vice-president of Mid-West Refineries, Inc., Grand Rapids, Michigan.

E. S. BLEEKER, chief geologist for the New York Production Division of Gulf Oil Corporation, is on a trip to South America.

CHESTER M. GARDINER, petroleum geologist and valuation engineer, has moved his offices from Suite 1024, Security Title Insurance Building to 530 West Sixth Street, Los Angeles, California.

RANSOME G. HOLLAND, production engineer, Phillips Petroleum Company, Bartlesville, Oklahoma, is now located at Smackover, Arkansas. Prior to February 1 he was division engineer at Ponca City, Oklahoma, for The Carter Oil Company.

W. C. THORN, who has been an independent operator at Long Beach, California, is now Texas manager for the Pearson-Sibert Oil Company, making his headquarters at Snyder, Texas.

H. STEWART DUEY, piping and instrument designer, formerly with Standard Oil Company of California at San Francisco, is now with Fluor Corporation. He is working temporarily in the Kansas City, Missouri, office of the company.

D. G. JACKSON, district superintendent for the Sunray Oil Company, has been transferred from Victoria, Texas, to Guthrie, Oklahoma. Before going to Victoria about a year ago he was with the company at Oklahoma City.

FRED W. RAMIN, who has been chief chemist for the Independent Refining Company, Arp, Texas, has joined the staff of the Ethyl Gasoline Corporation at Tulsa, Oklahoma, where he is an engineer in the gasoline testing department. Before going with Independent he was with the American Petroleum Company in Houston, Texas, for three years as a chemist.

WYATT L. WALKER, junior engineer with the Cities Service Gas Company, has been transferred from the oil pipe line division to the gas pipe line division of the company, and moved from Oil Hill, Kansas, to Lawrence.

IVAN G. BURELL, production superintendent at Owensboro, Kentucky, for the Ohio Oil Company, has been transferred to Marshall, Illinois, as division petroleum engineer.

F. W. ROBSON, formerly with The Carter Oil Company as head of the drafting department, has resigned to accept the position of assistant engineer with the White Eagle Division of Socony-Vacuum Oil Company at Wichita, Kansas.

C. P. PARSONS, vice-president of Halliburton Oil Well Cementing Company, talked on the subject, "Current Practices and New Developments in Cementing Oil Wells" before the Engineers Club of Tulsa at that organization's noon luncheon meeting on April 28.

RAY E. MILLER, Hanlon-Buchanan, Inc., Tulsa, Oklahoma, was elected president of the Natural Gasoline Association of America at the annual meeting in Dallas, Texas, recently. Other officers elected are: J. R. JARVIS, Lone Star Gasoline Company, Dallas, vice-president; HARRY A. ELLS, Cities Service Oil Company, Bartlesville, Oklahoma, vice-president; J. W. VAIDEN, Skelly Oil Company, Tulsa, vice-president. The Hanlon Award for meritorious service to the industry went to ALOIS KREMSER, assistant manager of research, Standard Oil Company of California, San Francisco.

ROBERT L. MARSTON has been made assistant production superintendent of the Sun Oil Company in the Dallas, Texas, division, to assist JOHN A. RITTER, general superintendent of production. Ritter has been given added executive duties since the recent death of M. B. SWEENEY. Ritter has been with the company since 1923 and since 1930 was assistant general superintendent until appointed to succeed Sweeney. Marston has been superintendent of the Rio Grande district of the company with headquarters at McAllen, Texas.

JOHN ROLAND has been appointed district manager at Wewoka, Oklahoma, by the Sinclair Prairie Oil Company. He has been at Winfield, Kansas, and succeeds C. S. ROSE, who has been promoted to division superintendent and transferred to Tulsa. Rose takes over the post made vacant by the transfer of D. M. INGALL to South America.

JAMES B. BROWN, refinery superintendent for the Bahrein Petroleum Corporation, Bahrein Island, is spending a 3-month vacation in the United States.

CARLOS ANDERSON, petroleum engineer, Continental Oil Company, has been transferred from Hobbs, New Mexico, to Mission, Texas.

FRANCIS F. HEBERT, graduate engineer at Louisiana State University, has become a junior petroleum engineer with the Humble Oil and Refining Company. He is stationed at Crowley, Louisiana.

CARL REISTLE, chief petroleum engineer for Humble Oil and Refining Company, recently spoke before the petroleum engineering department of the University of Oklahoma.

JOHN P. HAMMOND has joined the staff of the Mid-Union Drilling Company, Wichita Falls, Texas, as an engineer. He has been with Royal Petroleum Corporation, Tulsa, Oklahoma.

BROOKS DOZIER, cable-tool drilling contractor, has moved his offices from Vincennes, Indiana, to Carmi, Illinois.

G. A. PROBST recently was made purchasing agent of the Yale Oil Company at Billings, Montana. He has been assistant state purchasing agent, making his headquarters at Great Falls, Montana.

M. J. FITZGERALD, independent operator of Tulsa, Oklahoma, has moved his headquarters to Houston, Texas.

PAUL B. BROWNER is the new manager of drilling and production for Housh and Thompson, Houston, Texas.

GUY MABEE, independent operator and drilling contractor, has moved his headquarters from Mount Carmel, Illinois, to Evansville, Indiana.

TOM LEACH has resigned as district geologist for the Ohio Oil Company to open consulting offices at Bismarck, North Dakota.

R. J. RITNER, district manager at Bakersfield, California, for International Cementers, Inc., has been promoted to manager of the Pacific Coast division, Los Angeles.

JAMES M. BAGGS, who has been in the metals laboratory of the Wyoming State Highway Department, has accepted a position as assistant chief chemist of the Husky Refining Company, Cody, Wyoming.

WILLIAM R. DAVIS, of New York City and Houston, Texas, has been made president of the Panhandle Producing and Refining Company, Wichita Falls, Texas, succeeding ROY B. JONES, who becomes chairman of the board. Jones also will continue as president of the Panhandle Refining Company.

RICHARD H. PENCE, member of the engineering staff of the California Oil Administrator's office, has been called to active duty with the United States Navy. Pence holds the rank of lieutenant in the U. S. Naval Reserve and reported for assignment on May 5.

HARVEY J. LIDKEA, assistant chief engineer, American Brakeblok Division of the American Brake Shoe and Foundry Company, addressed the Pittsburgh section of the Society of Automotive Engineers at the Mellon Auditorium in Pittsburgh on April 22, on, "Brake Lining at Work."

M. J. EGAN recently was elevated from comptroller and office manager to vice-president and general manager

M. J. EGAN

of the Bridgeport Machine Company, Wichita, Kansas. The complete story was published in the April issue of *The Petroleum Engineer*.

PAUL E. SHAW of the C. F. Pease Company, Chicago, Illinois, is arranging visits to industrial plants in the Chicago area for members of the National Association of Purchasing Agents who assemble for their annual convention at the Stevens Hotel May 26 to 29, inclusive. Shaw, chairman of the plant visitation committee, has managed to schedule an interesting program, despite government restrictions affecting visitors this year.

J. H. TATLOCK, independent oil operator, is moving the office of the company from Ellis-Singleton Building to a new building on East Douglas Avenue, Wichita, Kansas.

HORTON T. PRUETT has resigned as petroleum engineer for the Railroad Commission of Texas to accept a position as engineer with the Coastal Engineering Service, Corpus Christi, Texas.

C. LANG PROCTOR, formerly in charge of operations for Sinclair of Mexico, and L. J. VAN DIJK, engineer with Caribbean Petroleum Company of Maracaibo, Venezuela, were guests of the Houston Chapter of Nomads at a luncheon at the Houston Club recently.

HASSIE HUNT, son of H. L. HUNT, independent operator, has been granted 90 days to get his business in shape to spend a year in the U. S. Army, having been called up for service by the Dallas draft board. Hassie operates on his own account, as well as jointly with his father, in East Texas, Louisiana, and Mississippi.

SAMUEL L. N. BURK, chief job analyst of The Atlantic Refining Company, made talks at general and sectional meetings of the Second Annual Southwestern Area Conference on Industrial Relations held at Houston, Texas, May 2 and 3. Among a group of five speakers at the general meeting of the conference Burk discussed "Better Understanding of the Wage Problem." Other speakers were CHARLES R. HOOK, president of the American Rolling Mill Company; LAWRENCE A. APPLEY, formerly of Socony-Vacuum Oil Company, and now counsel to the secretary of war; ARTHUR C. HORROCKS, president of the National Association of Foremen, and CAPT. A. A. NICHOSON, personnel director of The Texas Company. Burk spoke later in the conference before a special technical section on "Methods of Job Analysis and Evaluation."

J. WILLARD. LORD, safety engineer of The Atlantic Refining Company, served on a panel of safety experts in a commercial vehicle safety quiz conducted April 23 at Hotel Pennsylvania, New York City, during the 12th Annual Safety Convention and Exposition sponsored by the Greater New York Safety Council.

U. B. BOUCKE, controller of the company, was elected a vice-president at the organization meeting of directors of Tide Water Associated Oil Company recently. Other officers were reëlected as follows: President, WILLIAM F. HUMPHREY; vice-presidents, C. R. BARTON, L. F. BAYER, J. D. COLLINS, L. C. DECIUS, B. I. GRAVES, K. R. HANKINSON, GEORGE J. HANKS, L. D. JURS, R. B. PRINGLE, and EDWARD H. SALRIN; controller, U. B. BOUCKE; secretary, WILLIAM J. BURKER; treasurer, K. R. HANKINSON, and executive secretary, J. P. EDWARDS.

LAUGH WITH BARNEY

"Well, Jerry finally married that terrible red head."

"What got into him?"

"Buckshot."

A minister was loud in his praise of the fat and juicy bird his colored host served for dinner, and finally asked: "Where did you get such a fine goose?"

"Pahson," replied his host, "when you preaches a good sermon Ah doan ax you whar you got it. Ah hopes you'll hab de same consideration foh me."

Mistress: Did you enjoy your day at the seaside, Mary?

Mary: No, I didn't, mum; all the picture houses was full, so we had ter wander around the beach, and watch the ships all day."

"Did you ever hear an after-dinner speech that was really worthwhile?"

"Only once. Recently I dined with an old acquaintance and he said: "Waiter, bring me the check."

Hotel Clerk: Pardon me, Mister, but how did you happen to be named J. John B. B. B. Benson?"

Patron: I was christened by a minister who stuttered.

Clerk: No, madam, we haven't had any for a long time.

Manager (overhearing): Oh, yes; we have it madam. I will send to the warehouse and have some brought in for you.

(Aside to clerk) Never refuse anything. Send out for it.

As the lady went out laughing the manager demanded: What did she say?

Clerk: She said we haven't had any rain lately.

"Talk about Napoleon! That fellow Johnson is something of a strategist himself."

"As to how?"

"Got his salary raised six months ago, and his wife hasn't found it out yet."

Father: There's plenty of time for our daughter to think about marriage. Let her wait till the right man comes along.

Mother: Why should she? I didn't.

An old maid is a young woman who says no until she is too old to say yes.

The head of the firm was frowning over a letter. Calling his chief clerk, he said: "That new stenographer—you surely did not hire her on account of her grammar!"

"Grammar!" echoed the clerk. "Gosh, boss, I thought you told me to pick one out for 'glamour'!"

A naval officer fell overboard. He was rescued by a deck hand. The officer asked how he could best reward him.

"The best way, sir," said the gob, "is to say nothing about it. If the other fellows knew I'd pulled you out, they'd chuck me in."

Blessed are the meek . . . for they shall inherit the earth—less 26 percent for inheritance taxes.

"Can you help me select a gift for a wealthy old aunt, who is awfully weak and can hardly walk?"

Clerk: "How about some floor wax?"

Girls who keep on slapping faces
Don't see sights and don't go places.

Old Philosopher: Yes, sir, the best way to get the most out of life is to fall in love with a great problem or a beautiful woman.

Young Man (after a moment's thought): Why not choose the latter and get both?

Mother: What in the world is all this loud talking and arguing about in the living room?

Sonny: Aw, Grandpa's trying to show Pop how to do my homework.

The policeman walked from room to room, looking at the disarray. Drawers were dumped, rugs were kicked back. "Well, why didn't you realize the house had been robbed when you first saw this mess?"

Wife: "Why, I just thought my husband had been looking for a clean shirt."

STEWED!

My skin is all bloated,
It wrinkles—it sags.
I'm stewed to the limit—
The last of my jags.
But my heart's as gay
As a songbird in June,
I feel no remorse—
For I'm only a prune!

"I've stood about enough!" said the sentry as they amputated his leg.

A young man and his fiancee had wed and were spending their honeymoon at a large hotel. When bed time came the bride went to bed and the groom sat by the window and gazed at the moon and stars. The bride called to him and asked:

"Why don't you come to bed?"

He replied: "My mother told me my wedding night would be the most beautiful night of my life, and I'm not going to miss a minute of it."

"How about a date?"

"Goodness, no."

"Oh, I don't mean now. Some nasty wet winter afternoon when there's nobody else in town."

The new tool pusher was named Dodgin. He climbed out of his car for his first look at the wildcat and came on two of the crew sitting back of the core house smoking. One of the pair asked:

"Who are you?"

"I'm Dodgin, the new tool pusher," he replied.

"So are we. Sit down and have a smoke."

SPLITTING FEES

Lady: I guess you're getting a good thing o' tending the rich Smith boy, ain't ye, doctor?

Doctor: Well, yes; I get a pretty good fee. Why?

Lady: Well, I hope you won't forget that my Willie threw the brick that hit him.

WHERE IT WAS NEEDED

Willie was being measured for his first made-to-order suit of clothes. "Do you want the shoulders padded, my little man?" inquired the tailor.

"Naw," said Willie, "pad the pants."

PROUD FATHER

A young father stood over his first born's crib gazing at the sleeping infant. His wife saw in his face a mixture of emotion, rapture, despair, admiration, ecstasy, and doubt. Touched and wondering alike at this unusual parental attitude and his conflicting emotions, his wife arose, and with glistening eyes, slipped her arm through his and looked fondly into his face.

"A penny for your thoughts," she said in a tremulous voice.

"I don't see how they can do it," he replied.

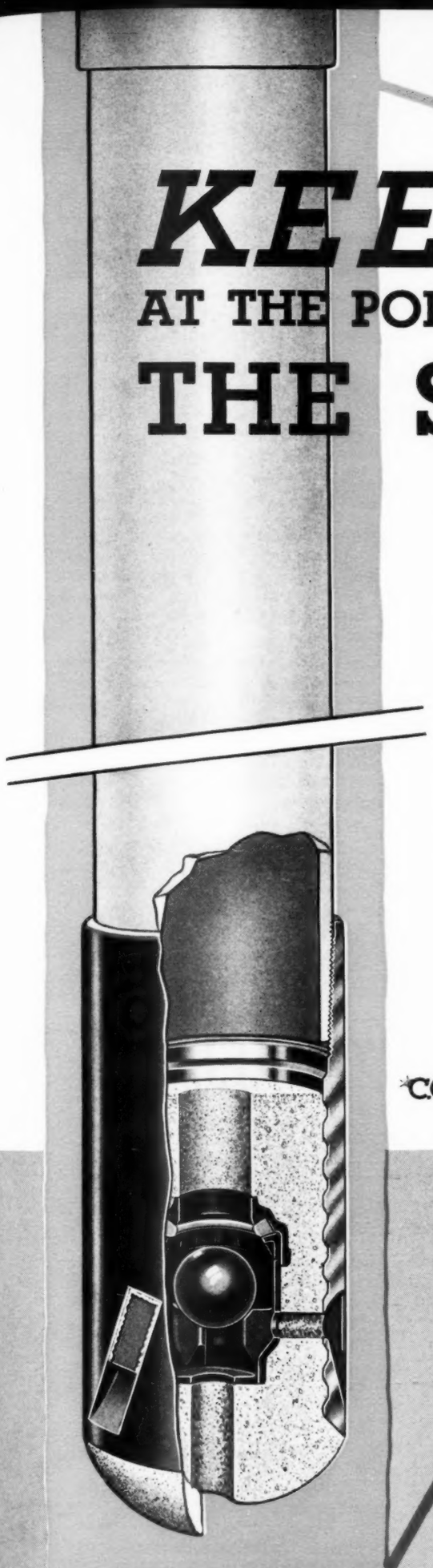
"Do what?"

"Make a crib like that for $3.49."

KEEP C.C.

AT THE POINT WHERE IT COUNTS..

THE SHOE JOINT



Product No. 120
Fig. L-28
Baker Cement Wash-Down Whirler
**Float Shoe*
**The Baker Wash-Down Whirler principle is also available in a Guide Shoe*

AND YOU CAN DO IT WITH A BAKER CEMENT WASH-DOWN WHIRLER SHOE

C. C. (CEMENTING CONTROL) is just as important (if not more important) in sub-surface phases of cementing casing as it is in *above surface* operations.

Above the ground, every step from "the mix" to "displacement," is carefully controlled. But when the slurry reaches the discharge point, the Shoe, it's in greater need of control than ever before—control to see that the slurry will go where it will do the most good—*entirely around the casing* at the critical cementing point, the Shoe joint. And that's just the CEMENTING CONTROL provided by the Baker Cement Wash-Down Whirler Shoe. When the slurry strikes the baffled whirler ports in a Baker Cement Wash-Down Whirler unit, it travels in a downward and then upward direction with a whirling motion that assures best possible distribution of a uniform body of cement entirely around the shoe and the shoe joint.

It is this efficient whirling action that reduces the hazard of channeling (and a possible recement job) to a minimum.

If you are not using Baker Cement Wash-Down Whirler Shoes, it will pay you to secure complete details from the nearest Baker Office or field representative. Also see page 222 of your 1941 Composite Catalog.

C.C. stands for CEMENTING CONTROL—Remember a Baker Cement Wash-Down Whirler Shoe gives you COMPLETE C.C.

BAKER CEMENT WASH-DOWN WHIRLER FLOAT SHOE PROVIDES 5 IMPORTANT FEATURES:

1. Ample Strength
2. Whirler Action for Washing Down Bridges
3. Efficient Cementing (CEMENTING CONTROL)
4. Positive Acting BALL-TYPE Back Pressure Valve
5. Easy Drillability

BAKER OIL TOOLS, INC.

Main Office and Factory: 6000 So. Boyle Ave.
Box 127 Vernon Station, Los Angeles, California

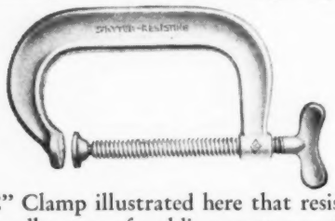
Central Division Office and Factory:
6023 Navigation Blvd., Box 3048, Houston, Texas

Export Sales Office: 19 Rector St., New York, N. Y.

MACHINERY and EQUIPMENT

Williams' "Spatter-Resisting" Clamp for Welding Service

J. H. WILLIAMS and Company, 225 Lafayette Street, New York City, are now offering a special "Spatter-Resisting" finish on the drop-forged



"C" Clamp illustrated here that resists the adherence of welding spatter to the body, swivel, and screw. These completely cadmium-plated clamps are available in 7 sizes, with capacity opening range from 2 to 12 in.

Globe Slush Pump Piston

THE Globe Slush Pump Piston, a new product for which several new features are asserted, has been announced by Globe Oil Tools Company, Los Nietos, California. In placing particular emphasis on its efficiency and economy, the company states that this new piston "fits the rods, fits the liners, assures maximum fluid per stroke and permits full power of the pump to be

utilized, and performs with utmost efficiency because of its perfect working arrangement between rods and liners. Its precision fit on all type rods prevents washouts and consequent rod failures," the manufacturer states.

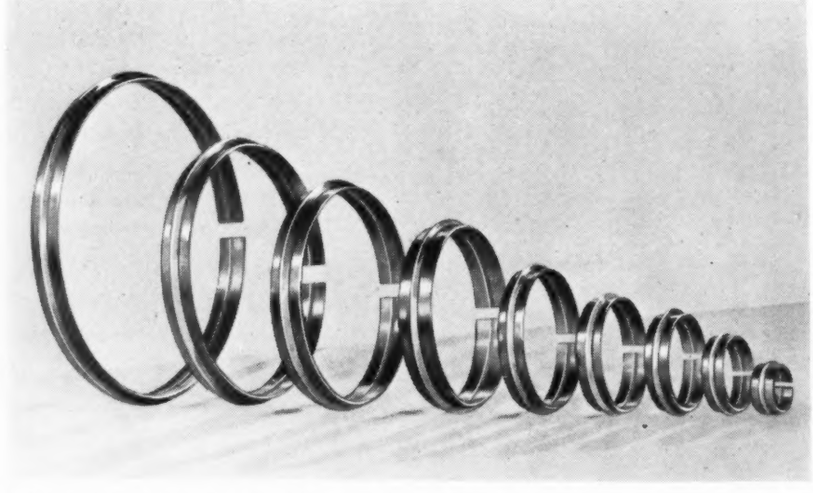
Strength is emphasized at all points of the Globe piston, it is pointed out. It consists of only five parts: the body, two rubbers, and two end plates. Forged-steel bodies and heavy end plates reinforce the rubbers on all sides except the surface, which wipes the liner. The rubbers are moulded around metal disks for added strength, and are held firmly against the center flange by threaded end plates. Rubbers are replaceable and, as a result, piston bodies may be used repeatedly inasmuch as they are relatively unaffected by the operation of the pumps. The savings made possible by this renewal feature are further emphasized by additional savings in transportation costs, and a reduction in inventories, the manufacturer points out.

Durability is a consistent quality of the rubbers, which are uniformly compounded from a tested formula offering maximum resistance to wear, pressure, and temperature. This in turn is a special advantage in "lip" construction, where it prevents premature wear and failure under pressure, it is stated.

Detailed information is contained in Bulletin No. 28, which may be obtained from the manufacturer.

Tube-Turns Welding Rings

TUBE-TURNS Welding Rings, just announced and illustrated herewith, offer an exact means of lining up and spacing pipe to obtain a 100 percent sound joint, according to the manufacturer, Tube-Turns, Inc., Louisville, Kentucky.



The ease and speed of using these rings save the welder hours of time and troublesome work, it is asserted.

No clamps, guides or fixtures are needed for supporting fittings and pipe for tack welding. The ridge on the ring spaces the welding ends exactly and automatically. The correct spring and rigidity of the ring holds it accurately in place for welding, it is stated.

Tube-Turns welding rings will align and hold together virtually any combination of fittings and pipe, the makers assert. This feature is especially helpful in field fabrication work, where clamps and fixtures found in ideal shop conditions are not so available, it is pointed out.

These rings also serve effectively in all shop work and are particularly useful in difficult fabrications where the operator would ordinarily have to spend hours lining-up joints properly before he can even tack weld, the manufacturer states.

One of the important features of these rings is that they can be used with all types of welding fittings and pipe joints—such as elbows, tees, reducers, caps, welding neck flanges, etc., and on straight pipe. A very common application of the rings is in the lining-up and welding of welding neck flanges to either pipe or fittings.

Tube-Turns, Inc., offers a new welding ring folder giving complete details that may be had by writing the manufacturer.

Yellow Strand

One strand of yellow in your rotary line marks it unmistakably as being made of the finest steel wire in the world, drawn to our own specifications—marks it as the highest product of a company that has devoted 65 years solely to wire rope making.

"Flex-Set" Preformed

When you ask for "FLEX-SET" PREFORMED Yellow Strand, you get something BEYOND the elasticity, toughness and strength of standard Yellow Strand—a line so limber that it's installed in less than no time and gets off to a quick start because it's practically pre-broken in—a line that's easily spliced, resists kinking, fatigue, whipping, and wickering.

Rotary Lines

Our engineering department keeps pace with every development in rotary drilling practice to provide you with lines that will give you uttermost value in service. Our engineers' recommendations have stepped up "ton-mileage" records amazingly in hundreds of instances. They'll help you, TOO.

BRODERICK & BASCOM ROPE COMPANY, ST. LOUIS
Houston Branch: 1311 Palmer Street, Houston, Texas

THE CONTINENTAL SUPPLY COMPANY
Mid-Continent and Rocky Mountain Distributors

Y-12

WHY NOT HAVE THE MOST EFFECTIVE PIPE PROTECTION?

The HILL-HUBBELL "factory process"!

COSTS NO MORE

When all items of expense are considered, the HILL-HUBBELL "factory process" costs no more. Your Coating-and-Wrapping is applied MECHANICALLY — INDOORS by the most efficient method known today. Your STEEL PIPE comes ready to lay, which eliminates protection delays caused by bad weather. For the money you pay out, you can have the best pipe protection available — SO WHY NOT HAVE IT?

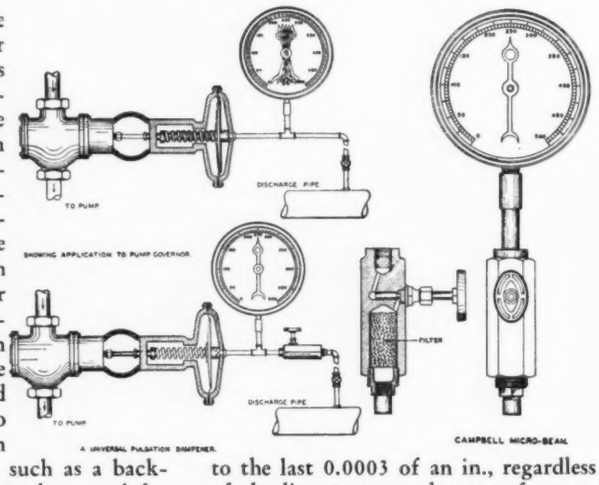
A request on your letterhead will bring a copy of The Book of PIPE PROTECTION, which describes our process in detail.

Laying 6⅝" O.D. Steel Pipe
New Orleans, La.

Schematic Construction of Specification TAX-I

GENERAL PAINT CORPORATION
HILL, HUBBELL & CO. • Division • Cleveland, Ohio
• EXPORT OFFICE: SAN FRANCISCO, CALIFORNIA, U. S. A. •

Micro-Action Valve for Governors and Gauges



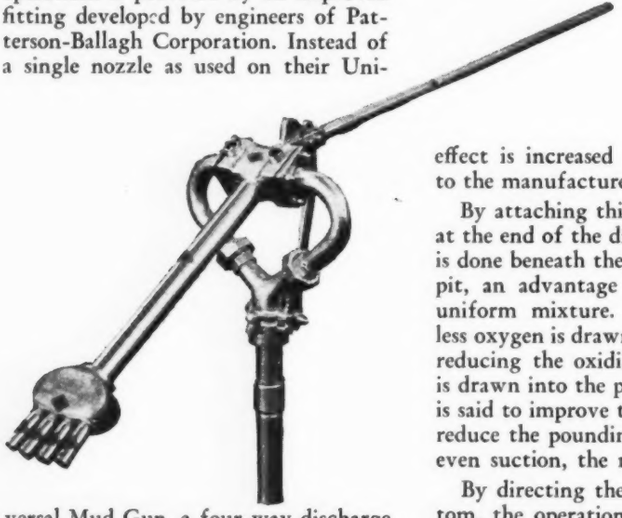
FOR dampening the pulsation of boiler plant pump governors and to eliminate "jitters" of the gauge hand, a device known as the Campbell Micro-Bean has been developed. It can be installed on the pressure line to the diaphragm of a pump governor for protection of the pressure gauge mechanism and tube, also the spring, diaphragm, and stem packing. It is also effective as protection to any control valve, such as a back-pressure or reducing regulator and for use with sensitive control instruments subjected to pulsating flow, the manufacturer states. The valve will handle steam, fuel oil, gas, water or other liquids, with simple adjustment for each viscosity.

The Micro-Bean consists of a solid brass body in which a filter is inserted for protection from foreign matter. The valve has an extremely slight taper so that very sensitive control of the shut-off is effected. This slight taper minimizes the tendency to pinch off under changing pressure conditions. The micrometric control of the opening enables the operator to obtain the closest approach to full shut-off down to the last 0.0003 of an in., regardless of the line content, the manufacturer asserts. In the Micro-Bean the solid metal body is said to minimize the effect of body strain. A 48-to-1 taper of the valve minimizes the effect of stem and screw compression strain. The device is universal in application for varied purposes to 3000-lb. pressure and will give any degree of stabilization desired by merely turning the valve, it is stated. Any scoring that might eventually take place (it is microscopic) can be simply ground-out by shutting off the valve completely two or three times.

The device is manufactured by J. A. Campbell Company, 645 East Wardlow Road, Long Beach, California. Literature is available.

Mud Gun Manifold

A MULTI-JET discharge for mud guns for rotary oil-well drilling operations is provided by an improved fitting developed by engineers of Patterson-Ballagh Corporation. Instead of a single nozzle as used on their Universal Mud Gun, a four-way discharge is attached, known as the Patterson-Ballagh Mud Gun Manifold. It consists of a steel assembly of a manifold and rubber-lined nozzles. The assembly is screwed into the discharge pipe. By breaking-up and directing the mud flow into smaller streams, the jetting effect is increased fourfold, according to the manufacturers.



By attaching this manifold assembly at the end of the discharge line, jetting is done beneath the surface of the mud pit, an advantage in making a more uniform mixture. It is believed that less oxygen is drawn into the mud, thus reducing the oxidizing effect. Less air is drawn into the pump suction, which is said to improve the pump action and reduce the pounding caused by an uneven suction, the manufacturer states.

By directing the mixing at the bottom, the operation causes less settling out of the mud weight material with resultant savings, it is asserted.

The mud nozzles are the standard size developed by Patterson-Ballagh in connection with mud mixing in tanks. These nozzles have extremely long life, due to the rubber used, which is the same compound as used in drill-pipe and casing protectors manufactured by the company, it is stated.

The manifold, being at the end of the discharge pipe, permits the discharge to be made anywhere in the pit and its direction can be changed to eject in a new position merely by pointing the gun. The mud gun commonly used is the double flow type in which there is no pump reaction or tendency to spin, it is stated.

Details may be obtained from the manufacturers, Patterson-Ballagh Corporation, 1900 East 65th Street, Los Angeles, California.

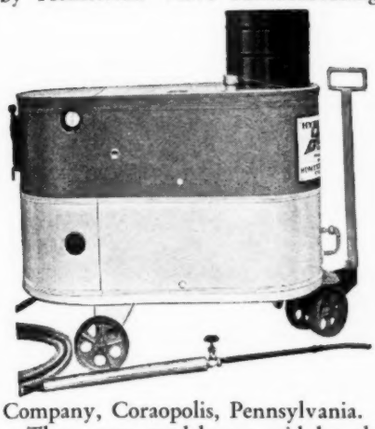
Linde Cylinder Truck

A NEW hand truck designed to carry an oxygen cylinder, an acetylene cylinder, and a complete welding and cutting outfit, has been announced by The Linde Air Products Company, a unit of Union Carbide and Carbon Corporation. This new truck, known as the Oxweld T-7 Two-Wheel Welding Truck, is light in weight, well balanced, and has 14-in. wheels equipped with semi-pneumatic rubber tires. The T-7 weighs considerably less than the company's former all-steel-wheel trucks that it replaces.

These features make the truck exceptionally easy to maneuver. It is easier to handle over rough places than trucks with even larger-diameter wheels, it is stated. The new design results in a 4½-in. reduction in overall width of the truck, permitting passage through narrower openings. As an added feature, the size of the removable metal tool box, for extra blowpipes, tips, goggles, and wrenches, has been increased.

Super Capacity Steam Cleaners

TWO new super-capacity Hypressure Jenny Steam Cleaners, Models J-L and J-M, have been announced by Homestead Valve Manufacturing



Company, Coraopolis, Pennsylvania.

These new models are said by the manuacturer to be more powerful than previous models, which means faster and more thorough cleaning of automotive parts, chassis, motors, machinery, floors, walls, exteriors of buildings, compressors, hoists, cranes, tank cars, etc.

A new simplified automatic compound feed, increased portability by the elimination of all dead weight, and greater simplicity of construction and operation, are among the many new features included in these models, according to the makers.

Penetrol

THERE is a method of utilizing the rust on rusty steel surfaces—and still painting over it—and of stopping further rust action. The method is the application of Penetrol directly upon the rust surface. It penetrates through and under the rust to the bottom of the pits of the steel and the spaces between the steel and the rust particles thus surrounding and locking the rust into a firm foundation for exposure coats. Moisture and air, which promote further rusting, are squeezed out as the Penetrol hardens from the bottom.

The blend of natural oils contains no volatiles, like naphtha or turpentine and a lighted match can be extinguished by lowering it into the liquid, it is stated. The absence of toxic or objectionable fumes and of explosion hazards is another advantage when painting must be done in confined spaces, it is pointed out.

For more detailed information on Penetrol as a protective primer and its other two uses as a reinforcing reducer for paints and a vehicle for aluminum pigments, write to the Flood Company, 6217 Carnegie Ave., Cleveland, Ohio.

SEALING PRESSURES SINCE 1888

No packing bills on this steam engine in 27 YEARS..

A letter from the Chief Engineer of a nationally prominent company.

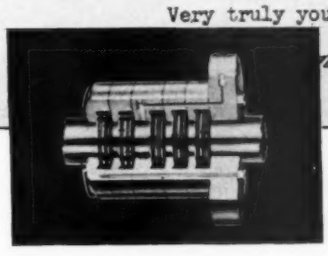
...lemen:

We have had in service on a steam engine for 27 years a set of your Cook's Metallic Packing -- Serial #48584 -- for which we need the tension spring including the guides on each end. The rod diameter is 4-1/4".

The packing is in good shape. It seems too bad that as long as it ran this long it could not have lasted a century and made a real record. However, we feel that 27 years of service is as much as anyone can ask for.

Very truly yours,

...nett



... and the original

COOK'S METALLIC PACKING

is good for many years more ..

THIS is another letter pulled at random from our file on COOK'S Metallic Packings—a file full of similar records of *years of service with never a penny for packing and rod maintenance.* Many engines and compressors come factory equipped with COOK'S Packings ... others are COOK equipped on request. When you order a new engine or compressor insure yourself against packing bills for years to come—specify COOK'S Packings. And for equipment in service, order from the equipment manufacturer or from us direct. *"It pays to use COOK'S Metallic Packings."*

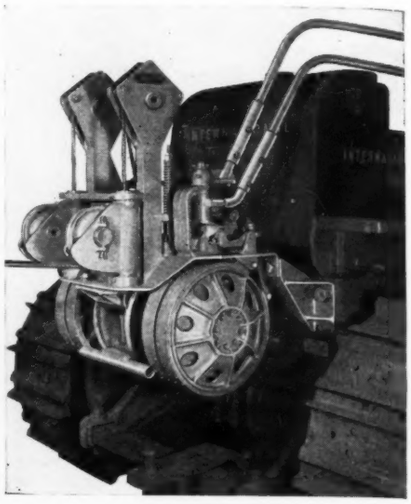
C. LEE COOK MANUFACTURING CO.
INCORPORATED
New York Cleveland Los Angeles Baltimore LOUISVILLE, KY. Chicago Tulsa New Orleans San Francisco

Bucyrus-Erie Power Control Unit Line

A COMPLETE line of single and two-drum power control winches for operating cable-controlled equipment with International TracTracTors and other tractors is announced by Bucyrus-Erie Company.

According to Bucyrus-Erie engineers, the arch enemy of dependable winch operation is excessive heat, and they assert that this trouble-maker has been completely routed in the new Bucyrus-Erie planetary-drive winch. Clutch and brake drums are separate and each drum has but one heat-generating surface; bands are external and contact 93.8 percent of the full circumference of the drum, spreading friction pressures over a large area so that less heat is generated at any one spot. All bands and drum friction surfaces are exposed to open air to assure prompt heat dissipation. Thus, say the designers, heat is carried off before it can build up to temperatures that would damage linings, ruin oil seals, or cause excessive expansion and contraction with its resulting effect on clutch and brake adjustment.

The wide, large-diameter external clutch and brake bands are interchangeable. One handy-to-reach adjustment on each band, in full view of the operator, compensates for wear.



Bands are easily replaced in the field with ordinary tools, and without disturbing a single oil seal or bearing, it is stated.

"Cushioned" starts and stops—thanks to big, generous brakes and clutches—lengthen rope life and protect tractors and equipment. Rope life is further safeguarded by large-diameter, properly aligned sheaves, and a long lead angle to assure smooth reeving on the drum. Swinging fairlead sheaves stay properly aligned with the lead cable even on short turns, it is asserted.

Full details of the new Bucyrus-Erie single and two-drum winches are given in the completely illustrated bulletin PCU-1 recently issued by the company. Copies of the bulletin may be obtained by writing to this magazine or to Bucyrus-Erie Company, South Milwaukee, Wisconsin.

Light Elevator for External Upset Pipe

A NEW, light-type center hinge elevator for handling external upset drill pipe has been announced by Web Wilson Oil Tools, Huntington

Park, California. This new elevator is particularly adapted to the lighter,

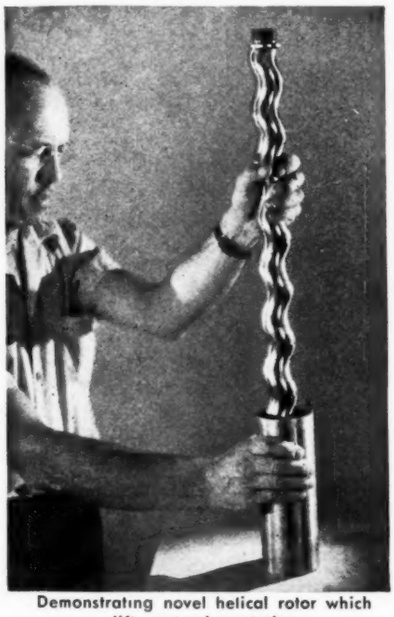
HAUL BIGGER LOADS
GET MORE TRACTION
SAVE ON EVERY TON-MILE
For real pulling power TWO driving axles under the load are far better than one.
With the THORNTON four-rear-wheel DRIVE, in addition to increased capacity and traction you get more flexible operation since you have two transmission ratios—one for power and one for speed. Your investment in equipment is 25 to 40% less, your operating and upkeep costs are from 30 to 50% lower. With THORNTON "Walking-Beam" spring design less shock reaches vehicle and load.
We can show you how to save with a truck equipped with THORNTON four-rear-wheel DRIVE. Users in scores of industries are lowering costs.
THORNTON TANDEM COMPANY
8701-8779 GRINNELL AVE.
DETROIT, MICH.
"When you need TRACTION you need THORNTON"

medium-depth drilling and the new portable and slim-hole rigs, the manufacturer states.

A large, sturdy latch and a heat-treated alloy-steel hinge pin absorb the horizontal stress due to the wedging action of the tapered pipe shoulder. A spring on the hinge pin automatically opens the elevator when the latch is operated, making it easy and fast to operate both in the derrick and on the floor, the makers point out. A new principle has been incorporated in the latch design that makes it impossible to open the latch with the elevator under load, it is stated, and the need for a safety catch on the latch has been eliminated. Large, convenient operating handles make for fast, safe operation.

Deep-Well Pump With Improved Chrome Helical Lifting Element

A FRENCH inventor, R. Moineau, conceived the idea of utilizing the force generated by a simple helical rotor to lift water, thus dispensing with impellers, plungers, pistons, and valves. The idea was adapted by an American manufacturer and a pump of novel design for deep water wells is the result. It was given its first field tests more than a year ago and since then numerous refinements have been added. The original pumping element consisted of a short helical rotor turning within a resilient stator that also was of helical shape inside. In the latest design of the pump, known as the Peerless Hi-Lift, the rotor is lengthened, thus compounding the lifting force so that relatively large capacities can be lifted from a small bore.



Demonstrating novel helical rotor which lifts water by rotation

The helical element illustrated is the size used in a 4-in. diameter pump column that can be inserted in a drilled well to a depth of 100 ft. or greater. This element is connected to a shaft that extends to the surface of the ground and is operated by a direct-connected motor on top of a built-in pump head. The shaft is supported within the pump's casing by water-lubricated bearings.

The stator in which the rotor element is locked is at the bottom of the pump column inside a metal sleeve. In case the pump is to be removed from the well for inspection or replacement, it is pulled out without the necessity of lifting out the casing.

By development of special reciprocating lathes, the new long rotors are precision turned, ground, and polished, to exactly fit the companion helical surface inside the non-rotating stator. No water slippage can occur, it is asserted.

Further details of the Peerless Hi-Lift Pump in its improved form may be obtained from Peerless Pump Division of the Food Machinery Corporation, 301 West Avenue 26, Los Angeles, California.

THE SOLUTION OF
YOUR DITCHING PROBLEMS

CLEVELANDS

Dig Anywhere — Anytime

Model "140" Ditcher. Digs 16" to 30" wide, 5' 4" deep, at speeds from ½ foot to 26 feet per minute. Soil-conveyor shiftable and reversible. Extra strong boom, wheel and buckets. Digs all types of soil successfully. Operates over roughest terrain. Special equipment for stripping pipelines.

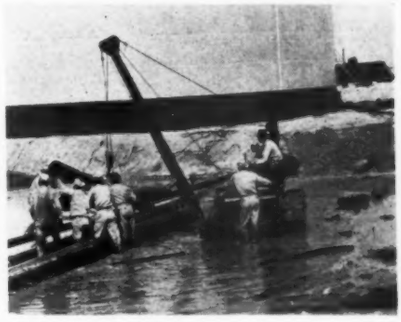
Put "Clevelands" on the line! You'll be the gainer. Whether it's a long main-line job, gathering lines or loops—"hot-spot" reconditioning or merely short, scattered routine work such as field lines or ordinary maintenance, you'll find "Clevelands" dependability, mobility and all 'round utility shows definite savings in time and expense

"Clevelands" accomplish this because practically every operation incidental to mechanical ditching has been speeded up ... waste motion eliminated ... precious minutes saved.

Here is soundly engineered equipment, ultra-modern in design, that is backed by a quality construction that is without equal.

COMPLETE THE JOB with "CLEVELAND" MODEL 90 BACKFILLER and PIPE-CRANE

A pipeline backfiller that's built to go anywhere. Affords faster cleanup on any size line. Instantly available for lowering slack-loops, pulling road-crossings, unloading or laying pipe.



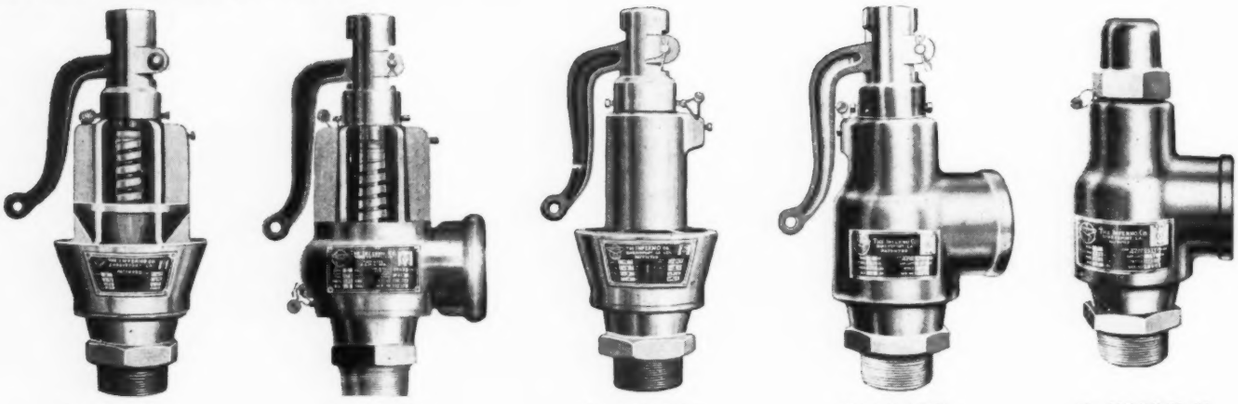
Write for complete information and specifications

THE CLEVELAND TRENCHER COMPANY

"Pioneer of the Small Trencher"

20100 ST. CLAIR AVENUE CLEVELAND, OHIO

New Safety "Pop" Valves



No. HC-TOES-A | No. HC-SOES | No. HC-TOCS | No. HC-SOCS | No. HC-SOCS-CS

HEREWITH are shown five new styles of safety "pop" valves that are said by the manufacturer to have relieving capacities 280 percent greater than the A.S.M.E. Code requirements.

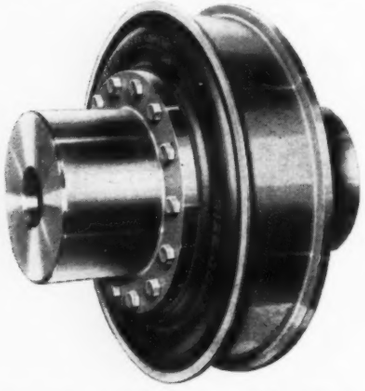
Style No. HC-TOES-A (top outlet exposed spring valve) has a cone deflector that diffuses the steam upward but away from the spring. Style No. HC-SOES (side outlet exposed spring valve) is the newest design, the spring being left exposed for inspection. All back-pressure is eliminated, even when the steam must be piped away, it is asserted. Style No. HC-TOCS is a top outlet valve with the spring enclosed. The side outlet closed spring valve (Style No. HC-SOCS) is used where steam must be piped away. The fifth style valve (No. HC-SOCS-CS) has a side outlet enclosed spring, is capped and sealed, and is generally used as a relief valve.

All of these high-capacity valves are set for the minimum blow-down designated by the A.S.M.E. Code, so that no steam is wasted. A lever and convenient pull cord is provided to encourage frequent tests. The valves have stainless steel stems impervious to corrosion, tough malleable iron bodies with tensile strength from 55,000 to 60,000 lb. per sq. in., nickel-alloy valves and seats, which resist rust, and chrome-vanadium, cadmium-plated springs. All are recommended for steam to 350 lb., 450°F., or for oil, water, and gas to 1000 lb.

The manufacturer has published a new bulletin (No. 11-C), which describes and pictures these high-capacity safety "pop" valves. The Inferno Company, Dept. PE, Shreveport, Louisiana.

Falk Airflex Coupling

THE Falk Corporation, Milwaukee, Wisconsin, announces a new flexible coupling, the Falk "Airflex." This coupling is especially designed for connecting Diesel, gasoline, or gas engines



to any type of driven machinery. It is an excellent coupling for use with motor-driven compressors, single-cylinder pumps, and other driven equipment of a similar fluctuating torque nature, according to the manufacturer.

The Falk Airflex Coupling is constructed to provide a flexible coupling in which the degree of resiliency can be readily changed to suit the exact requirements of a particular application, the manufacturer asserts. It decreases peak torque values when either the prime mover or driven equipment has a high fluctuating torque characteristic, it is stated.

The Falk Airflex Coupling consists of a special resilient rubber gland lined with a pre-moulded, pre-vulcanized cylindrical section especially treated to prevent air loss. This cylindrical lining is covered with multiple alternating layers of tough durable fabric and live rubber. The entire gland is permanently bonded to rugged steel inner and outer rims.

The gland is inflated to proper pressure through a specially designed standard threaded Schrader valve that will take any hand pump fitting or air nozzle. A rubber-covered metal cap prevents foreign material from entering the valve.

The degree of elasticity in this coupling can be varied by changing the air pressure. This frequently eliminates the necessity for adjusting the setting of the connected units, or making changes in shaft diameters and lengths or in the flywheel, to alter the torsional characteristics of the drive system.

Falk Airflex Couplings are made in six standard types so that the type best suited to the requirement can be applied with the minimum amount of special work.

Drilling and Fishing Safety Joint

A NEW safety joint, designed for use in both drilling and fishing, is announced by the Hydril Company, 714 West Olympic Boulevard, Los Angeles, California. A feature of this new joint is that the bore is large enough to allow wireline coring equipment, surveying instruments, and other tools to pass freely through it into the drill collar. The large diameter bore of the safety joint is obtained by the use of a positive-engagement clutch that employs a series of hardened, precision-ground taper pins as the means of locking the mating halves of the joint against relative rotation.

When the tool is made-up the amount of torque required to disconnect the two halves is permanently established by screwing them together to a predetermined tightness, and is considerably less than that re-

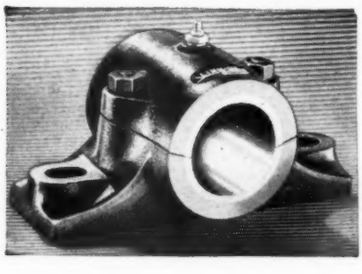
quired to unscrew a tool joint of corresponding size. The taper pin holes are then drilled and line reamed on the mating diameters of the box and pin members. The taper pins float free in the clutch member so that they can seek accurate individual alignment, and are held in place by pressure of a heavy spring. The correct fit thus obtained prevents back-lash and insures rigidity of the joint, the makers state.

If the tools become stuck, release is accomplished by means of a dart pumped down the drill pipe, or by dropping a dead weight if circulation is shut off. Pump pressure on the dart, or the dead weight, depresses the clutch, drawing the taper pins out of engagement. The two halves of the joint can then be unscrewed and the upper part of the string with the upper half of the safety joint removed from the hole. The dart or weight is retained in the upper half of the safety joint and is removed with the drill string.

Streamlined Bearing By Link-Belt

A NEW streamlined babbitted-bearing Common Flat Box (Series 2-1200), with maroon-colored crackle-finish housing, has been announced by Link-Belt Company, 2410 West 18th Street, Chicago, Illinois. Designed for moderate speed and power requirements, it is available from stock in 24 sizes, for shafts of ½ to 3 in. diameter.

Other design features pointed out by the manufacturer include:



Compactness, with proper metal distribution to assure maximum strength and rigidity within minimum overall dimensions.

Sloping surfaces between cap and base maintain concentricity and relieve the cap bolts of direct strain from side thrust.

Removable shims between base and cap provide for needed adjustment.

Design of cap reinforces cap bolt lugs by proper distribution of metal where holding strain is exerted.

Cap bolts do not protrude above top of bearing.

The babbitt is of a balanced formula, selected in operative tests, for maximum service.

Bore is broached to size with cap in place, to assure concentricity and proper running fit on shaft, with reduced friction and lower power consumption.

Bearing ends are finished to provide accurate bearing surfaces for collars, pulleys, gears, sprockets, or other limiting devices.

Bearing cap is tapped for grease cup or hydraulic fitting. A groove in cap bore assures efficient distribution of lubricant.

Base is accurately ground to very close tolerances, maintained from base to bore center.

Base is properly recessed to compensate for inaccuracies in surface of the structural support.

Heads of cap bolts are easily accessible, and they are securely anchored to prevent turning.

Elongated holes for base holding-down bolts provide adjustment for shaft alignment.

A new illustrated folder No. 1865 gives dimensional and price data, and copies will be sent to all interested persons on request.

Here are oilfield engines built for even greater endurance than prior Case models with records of running year after year in 24-hour duty at amazingly low upkeep. Equipped with automatic cut-outs which shut down if engine temperature goes up or oil pressure goes down, they protect themselves against mishap and neglect. Extra-well guarded against dust by Case-built air cleaner and long-life shaft seals, they resist wear better than ever before. Ask distributors or write factory for full information on new models "DE" and "LAE," 35 and 55 H.P. J. I. Case Co., Racine, Wis.

DISTRIBUTORS

Southwest Equipment Co.
Dallas and Kilgore, Texas

Leland Equipment Co.
Tulsa, Oklahoma

Howard Supply Co.
Los Angeles, Calif.

CASE
Oil Field Engines

Oil Well Supply Announces Promotions

William (Bill) Miskimins, sales manager of Oil Well Supply Company's Panhandle District for the last four years, has been appointed sales manager of the recently combined North Texas and Panhandle districts with headquarters at Wichita Falls, Texas. This new district comprises the branches formerly included in the separate North Texas and Panhandle districts, the latter with headquarters at Pampa, Texas.

Joining "Oilwell" in 1917 at Houston, Miskimins has been associated with the company's store and sales activities at various points in Texas, Louisiana, and Kansas. He is well acquainted in the North Texas area, having been district manager at Wichita Falls from 1932 to 1934.

D. R. (Ray) Smith, sales manager of Oil Well Supply Company's former North Texas District since 1939, has been transferred to "Oilwell's" general office at Dallas to fill an important post in the merchandise department.

M. F. (Mike) Hazel, sales manager of Oil Well's West Texas District for the last four years, has been appointed sales manager of the East Texas, North Louisiana, and Arkansas District with headquarters at Shreveport, Louisiana. Hazel jointed "Oilwell" in 1930 at the Oil City, Pennsylvania, manufacturing plant. He covered many of the oil fields of Oklahoma and Texas, first as a service engineer and later as a sales engineer. In the latter capacity he became widely acquainted throughout East Texas, North Louisiana, and

WILLIAM MISKIMINS

M. F. HAZEL

S. E. SNOW

Reilly

Primer and Pipe Enamel

. . . MAINTENANCE COSTS Reduced to the Minimum

The best way to insure low maintenance charges for water, gas and oil pipe lines is to provide *dependable protection against rust and corrosion* due to soil acids and electrolysis. Dependable protection means pipe coatings which bond firmly to the metal, and safely withstand temperature variations without sagging in extreme heat or cracking under severe cold. Such coatings are REILLY PRIMER and PIPE ENAMEL. They are easy to apply, and are comparatively low in cost. Write for literature.

Reilly COAL TAR PRODUCTS

REILLY TAR & CHEMICAL CORPORATION

Executive Offices: Merchants Bank Building, Indianapolis, Indiana

2513 S. DAMEN AVENUE, CHICAGO, ILLINOIS 500 FIFTH AVENUE, NEW YORK, N. Y. ST. LOUIS PARK, MINNEAPOLIS, MINN.

FIFTEEN · PLANTS · TO · SERVE · YOU

Arkansas, where he was located for several years before he was made sales manager of the West Texas District.

S. E. (Red) Snow, manager of the company's Houston, Texas, store since 1938, has been appointed sales manager of the West Texas District with headquarters at Odessa. This promotion brings Snow back to the area in which he represented "Oilwell" from the time he joined the company in 1926 at Best, Texas, until he transferred to Beaumont in 1935 as manager of that branch.

Boezinger Made Vice-President Merco Nordstrom

H. Boezinger, for several years district manager in Los Angeles, California, for the Pittsburgh Equitable Meter Company of Pittsburgh, Pennsylvania, has been elected a vice-president of Merco Nordstrom Valve Company.

H. BOEZINGER

Boezinger is a graduate of Stanford University. Prior to his affiliation with Merco Nordstrom Valve Company he was engaged in petroleum engineering both in the San Joaquin Valley and Southern California. He has been associated with the Merco Nordstrom Valve Company since its early development and expansion in the oil industry. Boezinger's additional activities will cover the entire west coast.

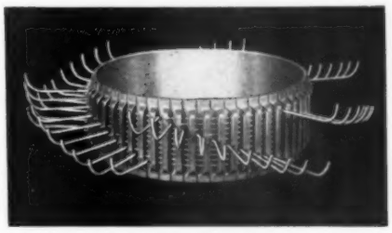
Acquire Industrial-Scientific Supply Company

Industrial Scientific, Inc., has announced the acquisition of the Industrial-Scientific Supply Company (Division of Fort Worth Laboratories). Industrial Scientific, Inc., has offices at 824 Monroe Street, Fort Worth, Texas, and 1302 Dallas Avenue, Houston, Texas.

B and W, Inc., Publish Bulletin

A new 8-page bulletin describing the usage of wall-cleaning guides in connection with the primary cement job has been released by B and W, Inc. The opening pages are in the form of a technical sales presentation, with large graphic sketches of well sections. The bulletin describes the construction, placement, and the many field usages of the guides.

Copies of Bulletin 102 may be obtained by addressing B and W, Inc., at any one of their three offices: 3545 Cedar Avenue, Long Beach, California;



302 M. and M. Building, Houston, Texas, and 1703 North Port Avenue, Corpus Christi, Texas.

DO YOU GUESS
or *Do You* Know?

the subsurface information about YOUR wells
that means YOUR LOSS or YOUR PROFIT

TO operate your oil properties in an efficient and economical manner, it is necessary to have all possible information concerning the reservoir conditions and physical properties of the well fluid. With E.L.I. Subsurface Recording Instruments this information is quickly available.

Accurate records of bottom hole pressures give the basis for most economical producing rate. Temperatures in the well reveal information of importance in cementing, as well as in producing and samples of well fluid taken under reservoir conditions can then be analyzed. The information secured from these tests is used to determine fluid movement in the reservoir, well spacing, ultimate recovery, economical separator pressure and other vital information.

Supplementary E.L.I. Laboratory Testing Equipment consists of:

- **MERCURY PUMP**
- **PRESSURE VOLUME CELL**
- **GAS-OIL RATIO EQUIPMENT**
- **PRESSURE VISCOSIMETER**

Our latest bulletin CATALOG - G *is a condensed reference on this and other E.L.I. Equipment in World-Wide use . . . write for it.*

1¼" O. D. SUBSURFACE PRESSURE GAUGE measures pressure within well bores to an accuracy of 0.5%. Maximum and Clock recorder types.

HIGH PRESSURE SUBSURFACE SAMPLER designed to secure samples within well bores at pre-determined depths and to retain them under pressure.

SUBSURFACE RECORDING THERMOMETER for measuring and recording temperatures in fluid columns within well bores. Optional temperature ranges of 180° F. are available.

ALL E.L.I. SUBSURFACE RECORDING INSTRUMENTS DESIGNED TO OPERATE IN 2" TUBING
(⅞" O.D. Pressure Gauge available on order to operate in 1½" tubing.)

E.L.I. is one of the largest geophysical research organizations in the world, devoted primarily to the problems of the Oil Industry.

Within ONE organization E.L.I. offers complete facilities for Research, Design and manufacture of precision instruments and equipment to locate and increase the production of oil—decreasing costs through conservation.

If you are not receiving the *E.L.I. Engineer*, send us your name. This publication will keep you informed on new E.L.I. Equipment and Services.

Engineering Laboratories, Inc.

CONSULTING ENGINEERS & MANUFACTURERS

TULSA, OKLAHOMA, U. S. A.

Heads California Oil Producers Agency

Lawrence Vander Leck, whose experience in the California oil industry began as a roustabout in the oil fields after graduation from the University of California as a geologist in 1915, has been elected president of Oil Producers Agency of California to succeed L. L. Aubert.

In accepting the presidency of the organization, Vander Leck paid high praise to Aubert, who, he said, "had worked tirelessly in behalf of the industry not only as Agency president, but also in many other activities."

Vander Leck is at present senior vice-president and a director of the Fullerton Oil Company, with which company he has been associated since 1920, after two years with the then State Mining Bureau, now State Division of Oil and Gas, of which he had become chief geologist. During this period, Vander Leck wrote one of the first surveys of oil resources in the state, which was issued by the Mining Bureau as Bulletin 89, "Petroleum Resources of California."

From 1935 until the middle of 1940, Vander Leck was active in the voluntary conservation program of the California industry as chairman of the Central Committee of California Oil Producers, the predecessor committee to the present Conservation Committee of California Oil Producers, which administers curtailment activities in the state. He is now a member of the Conservation Committee and a director of both the California Oil and Gas

LAWRENCE VANDER LECK

Association and the Independent Petroleum Association of America.

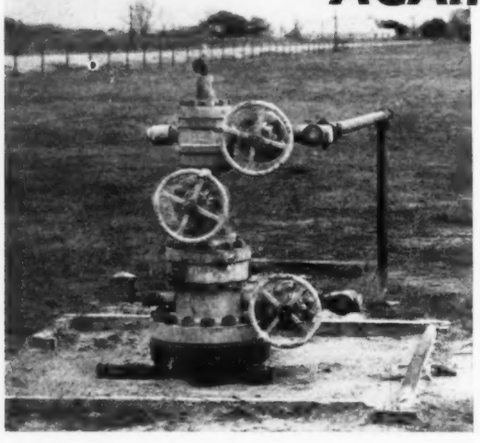
Rush M. Blodget, who has been general manager and executive vice-president of the Agency since its organization by a number of independent oil producers in the chaotic days of 1932, was again re-elected to that position.

Four vice-presidents also were elected, three of them being re-elected. Re-elected were M. A. Machris, Bandini Petroleum Company; L. A. Cranson, Honolulu Oil Corporation, and C. A. Johnson, Holly Development Company. C. P. Watson, Seaboard Oil Company, who has been an Agency director for the last several years, was a newly elected vice-president. W. A. Russell, Seaboard Oil Company, was re-elected secretary-treasurer, and D.P. Murdy, Bandini Petroleum Company, assistant secretary-treasurer.

Four new directors were elected by the Agency members. They are: Dwight G. Vedder, Vedder Petroleum Corporation; Dewitt Knox, MacMillan Petroleum Company; W. D. Waltman, Franco-Western Oil Company, and Cecil Rood, McVicar-Rood group.

Eight directors whose terms had expired were re-elected. They are: A. E. Bell, A. E. Bell Corporation; Rush M. Blodget; L. A. Cranson, Honolulu Oil Corporation; J. J. Doyle, Doyle Petroleum Company; W. H. Geis, Arrowhead Oil Company; R. E. Havenstrite, California Western Oil Company; C. A. Johnson, Holly Development Company, and Lawrence Vander Leck.

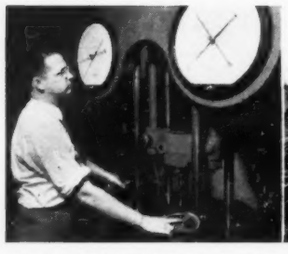
LIKE AN INSURANCE POLICY AGAINST TROUBLE



...The extra uniformity of McEvoy Equipment!

Uniformity is the difference between *really good* and *fairly good* completion equipment. Any of it will work most of the time but the extra uniformity of McEvoy completion equipment gives satisfactory service during and after completion, an unusually high percentage of the time.

Here are a few of the reasons for the uniformly high quality of McEvoy Well Heads.



STEEL IS TESTED for chemical analysis and strength. Alloy steel, selected for high strength and shock resistance, is used and rigid specifications insure uniformity.

CASTINGS ARE CHECKED for uniform hardness and size as well as soundness. Uniformity of these castings means freedom from leaks and other troubles on your lease.

RIGID INSPECTION of the finished product prevents any out-of-tolerance part from getting by. McEvoy's rule, which is never to let anything — no matter how slightly out of tolerance—get by, pays dividends in the long run.

Why not start taking advantage of the extra uniformity of McEvoy Well Heads? If you want further information look on pages 1755-1778 of your 1941 Composite Catalog—or, better yet—call your nearest McEvoy representative. He will answer any questions you may have.

Sold Through Supply Stores Everywhere

McEVOY

COMPANY

Texas at Milby St., Houston, Texas

EXPORT OFFICE

30 Church Street, New York, N. Y.

Austin W. Clark Elected Vice-President National Supply

The National Supply Company has announced the election of Austin W. Clark as vice-president. Previous to joining National Supply in August, 1940, as assistant vice-president, Clark, who was born in Anaconda, Montana, and attended the University of California, had been associated for four years with Sears, Roebuck and Company, Chicago, as assistant comptroller. Prior to that time, he was for 14 years with the Hearst publications in New York City, as comptroller and treasurer, and was also for four years with the Cerro de Pasco Copper Corporation in Peru, South America.

AUSTIN W. CLARK

E. H. Anchors to Birmingham District

E. H. Anchors, formerly manager of the Oklahoma City, Oklahoma, district of Air Reduction Sales Company has been appointed manager of the Birmingham district. Anchors began his career 16 years ago with the Commercial Acetylene Supply Company. He was southern manager of this company when it was acquired by Air Reduction. Since that time he has served as manager at the Atlanta and Oklahoma City district offices.

E. H. ANCHORS

LeTourneau Promotions

R. G. LeTourneau, Inc., Peoria, Illinois, announces the appointment of Walter L. Schump to its advertising staff. Schump takes over the duties of former assistant advertising manager, A. Robert Thomson, who has been promoted to the training division of the sales department. For the last five years Schump has been associated with The Denver Equipment Company and The Mine and Smelter Supply Company in charge of export sales and export sales promotion.

Other changes in the department promote Paul R. Miller to national copy. Miller's News Bureau activities have been taken over by Eugene E. Weyeneth.

JUMPY DIALS
are a
THING OF THE PAST

With Abercrombie Pressure Gauges

This fellow didn't have to get within two feet of this mud line gauge to see that the pressure was 1000 pounds. He could see that from the driller's position, from where the picture was made . . . or from a distance of 30 feet away. He's looking for a "jittery" movement of the dial, and he isn't finding any, thanks to the exclusive design which dampens pump pulsations over the entire pressure range, without adjustments. And the gauge is not affected by external vibrations, such as shaky derrick floors.

It's the oil field's most popular pressure gauge, because it's the oil field's most practical pressure gauge.

Made in Type D for mud line drilling service (as shown here) and Type F for small pump service, such as cementing, acid and boiler feed pumps and truck mounted pumps for shallow drilling.

FLUID-PISTON SLUSH PUMPS
ABERCROMBIE PUMP CO.
Gulf Building Houston, Texas

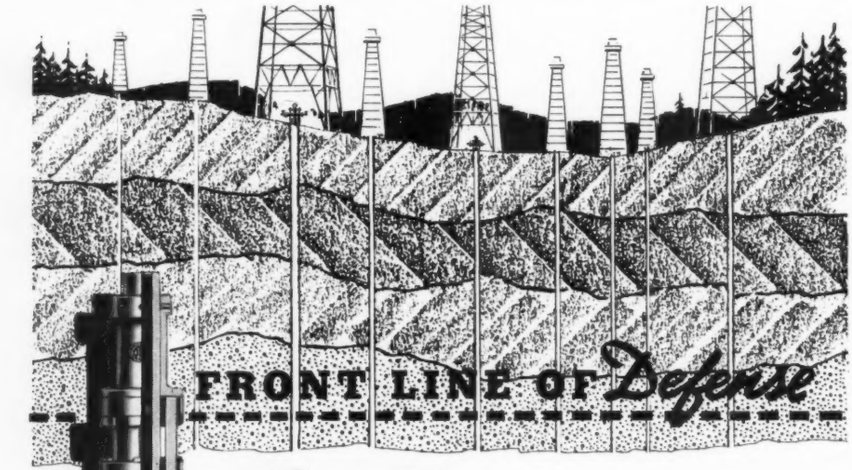
ABERCROMBIE PRESSURE GAUGE

Hoffman Elected Vice-President Link-Belt

Alfred Kauffmann, Link-Belt Company president, announces that with a view to making the general office organization a more effective aid to plant sales managers, the board of directors has elected Ralph M. Hoffman a vice-president, delegating to him the general direction and supervision of sales for the company.

Hoffman, a mechanical engineer, University of Minnesota, 1911, has been assistant to the president since January, 1940, with headquarters at 307 North Michigan Avenue, Chicago, Illinois, where he will continue to have his office.

He joined the Link-Belt organization in 1923 as manager of Link-Belt Meese and Gottfried Company's Seattle branch. He served in this capacity until 1931, the name of the Pacific Coast subsidiary meanwhile becoming Link-Belt Company Pacific Division; and from 1931 to 1939 served as vice-president and sales manager of this subsidiary, with headquarters at San Francisco.



Sub Surface CONTROL
WITH
OTIS TUBING SAFETY VALVE

The front line of defense for producers is at the bottom of the well. Here the Otis Tubing Safety Valve will guard your wells . . . shutting them off automatically should any destructive force damage surface connections.

The instant the rate of flow exceeds the predetermined rate the valve stops flow through the tubing. It may be reopened by equalizing pressures above and below.

Protect your flowing wells, equipment and adjoining property with a positive front line defense . . . the OTIS Tubing Safety Valve.

OTIS
PRESSURE CONTROL, INC.
DALLAS, TEXAS

Branches: Oklahoma City, Okla.; Houston, Texas; Hobbs, N. M.

Representatives: Otis Eastern Service, Inc., Wellsville, New York; Western Pressure Control, Inc., Los Angeles, California

Export Office: 74 Trinity Place, New York City

OTIS PRESSURE CONTROL SERVICE "Don't Kill Your Well" Call OTIS

New Kobe Gulf Coast Representative

The appointment of C. E. Buchner, Jr., as district representative in charge of sales and technical activities for Kobe, Incorporated, in the Gulf Coast and Southwest Texas areas has just been announced. Buchner will

C. E. BUCHNER, JR.

make headquarters at 1813 Esperson Building, Houston, Texas.

Buchner attended the School of Petroleum Engineering at Tulsa University and after graduating joined the engineering department of the Sinclair-Prairie Oil Company. Later he became interested in technical and sales work involving pumping equipment.

Manager Air Reduction District

M. G. Wicker, formerly connected with the Baltimore office of Air Reduction Sales Company, has been appointed manager of the Oklahoma

M. G. WICKER

City, Oklahoma, district. Wicker's 11 years with Airco has given him wide experience in the oxy-acteylene welding and cutting industry.

Joins Hissom Drilling Company

R. E. Hissom, who has been with Taber and Coleman, Shawnee, Oklahoma, as superintendent of drilling, recently joined the Hissom Drilling

R. E. HISSOM

Company as vice-president and superintendent of drilling. His headquarters are at Great Bend, Kansas.

Hissom first became connected with the oil industry in 1926 working as a roughneck for his brother, Wiley B. Hissom, who is head of the Hissom Drilling Company. Subsequently he became a driller with various companies and five years ago joined the staff of Taber and Coleman.

E. W. Burbank Passes Away

Edward W. Burbank, 52, former manager of Allis-Chalmers Manufacturing Company's Dallas, Texas, district office from 1922 to 1940, died

EDWARD W. BURBANK

April 20 after a prolonged illness that followed a stroke he had suffered in December, 1939. He began with the company as a student apprentice in 1911 after graduating from Tulane University, and served in a variety of engineering and sales work. He was a member of the American Society of Mechanical Engineers and had been on its board of managers, and was a member of the American Institute of Electrical Engineers. He was president of the University Club of Dallas for five years.

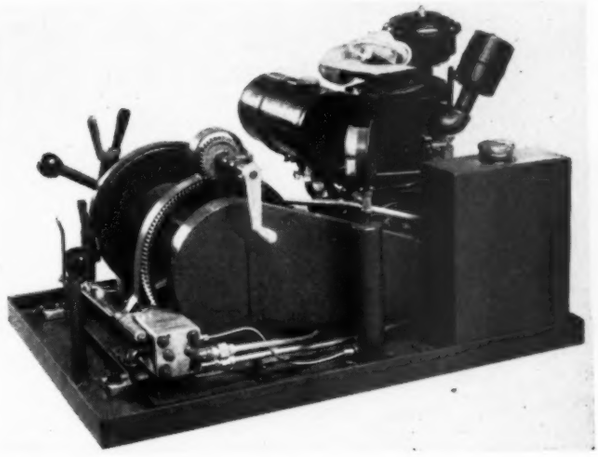
O. W. Jones Steps Up With Central Power and Light

O. W. Jones, who for many years has been electric power sales supervisor of Central Power and Light Company, Corpus Christi, Texas, will become head of the commercial and industrial power department of this company on May 1.

Well acquainted in petroleum and industrial circles throughout Texas, Jones has been in contact with industrial users of power in this area for many years. For the last 14 years he has been engaged in industrial power work for Central Power and Light Company. Previously he was with the Texas Power and Light Company.

Jones is also past president of the Petroleum Electric Power Association.

Mathey Type E Measuring Line Reel



Mathey Specialized Units

for:

Measuring Depths of Wells . . . Locating Fluid Levels and Locating Obstructions . . . Running Well Shooting Equipment . . . Gas Testing

. . and . .

Pipe Beveling by Oxy-Acetylene

All specialized equipment designed and manufactured to better than A.P.I. specifications for strength of machinery and quality of materials. We are equipped to design or manufacture to your specifications any specialized equipment in this field.

— Write for Catalog and Price List —

C. A. MATHEY MACHINE WORKS

Phone 3-3623 212 South Frankfort Tulsa, Oklahoma

LeTourneau Purchases Avery Farm Machinery Plant

R. G. LeTourneau, Inc., the world's largest manufacturers of heavy grading equipment, announces the purchase of the Avery Farm Machinery Company plant, located adjacent to the present LeTourneau factory in Peoria, Illinois. The sale includes all buildings and equipment of the Avery company with the exception of two buildings that were previously sold. The Avery company was once the largest tractor manufacturing plant in the world. The property has a frontage of 1300 ft. and will add 282,000 sq. ft. of floor space to the present LeTourneau plant.

The new quarters will house the production lines for the manufacture of the Tournapull, newest LeTourneau innovation in high-speed earthmoving and of the power control units that supply the power for all LeTourneau machines.

Frolic of C. N. G. A. To Be June 7

Under chairmanship of H. E. Leedy of the Crane Company, the committee in charge of the program for the 1941 June Frolic of the California Natural Gasoline Association announces the event will be held at the Riviera Country Club, Santa Monica, California, June 7.

This annual sports-fun fiesta will find the daytime devoted to a sports program with the first of the golfers teeing off at 8:30 a.m., a program of diversified sports events during the afternoon featuring a baseball game between the Majors and Independents, volley ball, horseshoes, and badminton. Tired and thirsty sportsters will find refreshments available without charge during the day. The evening program will feature a banquet to be followed by a specially arranged show.

According to Leedy, whose committee consists of Gordon Greene, Robinson Orifice Fitting Company; Walt Landis, Crane Company; George Christian, Crosby Steam Gage and Valve Company; Harry Fiske, Ingersoll-Rand Company; Glenn Gill, J. B. Gill Corporation, and Harold Dresser, Fluor Corporation, the event is open to all natural gasoline, refinery, natural gas and men from allied industries interested in attending. Those desiring information are advised to address George L. Tyler, California Natural Gasoline Association, 510 West 6th Street, Los Angeles, California.

GENUINE Grizzly Rotary Blocks *Factory installed on Steel bands* are available for all types of brakes and to fit any drum diameter. A service as close to you as your nearest supply house, that enables you to turn in your old, worn-out bands for guaranteed new steel bands, made to exact specifications for any specific type of drawworks . . . and factory lined with high quality Grizzly Rotary Brake Blocks of the correct thickness, width, length and radius. This Grizzly Brake Block Band Exchange Service is the scientific solution to your brake lining troubles whatever equipment you are using. It will save time, money and labor and assure you better performance—safer—brakes and longer-life. It costs no more. Ask your nearest supply house for additional information.

GENUINE GRIZZLY ROTARY BLOCKS *factory installed on* STEEL BANDS *At No Extra Cost*

E. M. SMITH COMPANY
600-650 South Clarence St., Los Angeles, California, U. S. A.
Complete Stocks Maintained in Our Warehouses At:
407 Velasco Street, Houston, Texas — 1621 East Yellowstone, Casper, Wyo.
1008 S. E. 29th Street, Oklahoma City, Okla.
Export Office: Continental Emsco Company, 30 Rockefeller Plaza, New York City
Distributed by Leading Supply Companies.

GRIZZLY

I. C. Lawless Made Sales Manager Bridgeport Machine

In a general streamlining move designed to increase efficiency throughout its distributing and service organization and to bring a more useful, a more flexible, and a more economical service to its customers, Bridgeport Machine Company, Wichita, Kansas, announces that its general sales department, purchasing, traffic, claim, and publicity departments, have been combined under one head, the sales manager. I. C. Lawless, who has been in

I. C. LAWLESS

charge of the company's advertising and public relations activities for the last nine years, has been advanced to the position of sales manager.

Lawless assumes his new position with a broad background of experience and training. He joined Bridgeport in 1919 as general auditor under the original company partnership of J. A. Woods and Ed Boyd, was promoted to the position of credit manager, and a number of years later to the position of sales manager, leaving this work and the company after several years to engage in independent advertising and general sales promotional work prior to returning to the company in 1931.

Slater New Kobe Representative

The appointment of W. F. Slater as Tulsa district representative to fill the vacancy created by the transfer of H. K. Ihrig to Mount Vernon, Illinois, as

W. F. SLATER

district manager in charge of the company's activities in that area, has been announced by Kobe, Incorporated, manufacturers of the Kobe Hydraulic Pumping System.

Slater's well-rounded and diversified experience with pumping problems in both the Mid-Continent and California fields makes him ably qualified to fill his new position. After attending the schools of engineering at Oklahoma University and Tulsa University he joined the Slater Oil Company and was in charge of their operations in the Glenpool area. In 1936 Slater became associated with the S. M. Jones Company in Tulsa as sales representative and in 1938 was sent to California in charge of that company's California operations. Later, he was associated with the Walter O'Bannon Company as advertising manager, which position he held until his appointment as Tulsa representative for Kobe.

E. W. Heinrich Joins Buda Organization

E. W. Heinrich, for many years connected with the export business of several American companies, has been named a divisional export manager for the Buda Company of Harvey, Illinois, according to R. K. Mangan, executive vice-president. Heinrich will have charge of Buda's export business between Mexico and the equator. He is former divisional export manager for the Caterpillar Tractor Company of Peoria, Illinois, and Yale and Towne Manufacturing Company in Connecticut, is a graduate of Yale University, and comes from Atlantic City, N. J.

George H. Koons, division export manager for Buda for many years, will have as his territory everything in South America below the equator and will establish headquarters at Rio de Janeiro and later in Buenos Aires.

R. B. Anderson, manager of the export division of Buda, points out that his company has decided to place great emphasis upon the development of business in Latin-America, where the demands at present are very great for railroad supplies, Diesel, and gas engines and such material as Buda produces.

Koons formerly represented Buda in Europe. He spent last summer and autumn in South America. Heinrich has had extensive experience in Central and South America.

The Petroleum Engineer

Is Available Through Subscription Only

IT IS NOT FOR SALE
ON THE NEWS STANDS

Shakin' Shale OUT OF MISSISSIPPI MUD

• When this operator rigged up for a deep wildcat test well in the Mississippi river swamps, he selected the best available rotary drilling equipment money could buy . . . including mud screens. This picture shows the dual hookup of Link-Belt NRM-124 vibrating mud screens doing a good job of mud-conditioning.

This unique dual unit consists of two 24" x 48" mud screens, mounted on skids as one unit, and having but one mud-collecting tank and inlet chute. Each screen panel is vibrated independently, although driven from a single source of power.

Write today for Folder No. PE-1872-A, which gives full mechanical details and operating advantages.

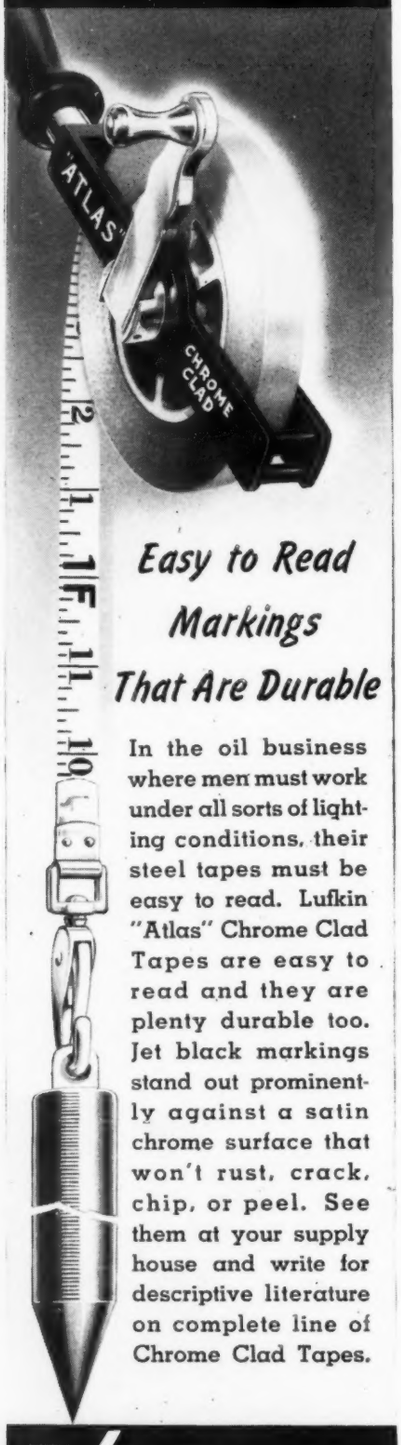
LINK-BELT COMPANY

Philadelphia, Houston, Dallas, Los Angeles, New York, Toronto. Sold by most supply houses.

8548

LINK-BELT MUD SCREEN

"ATLAS"
CHROME CLAD
STEEL TAPES



Easy to Read Markings That Are Durable

In the oil business where men must work under all sorts of lighting conditions, their steel tapes must be easy to read. Lufkin "Atlas" Chrome Clad Tapes are easy to read and they are plenty durable too. Jet black markings stand out prominently against a satin chrome surface that won't rust, crack, chip, or peel. See them at your supply house and write for descriptive literature on complete line of Chrome Clad Tapes.

LUFKIN
SAGINAW, MICHIGAN · New York City
TAPES · RULES · PRECISION TOOLS

H. H. Brown Heads New Frick-Reid Department

H. H. Brown, formerly assistant purchasing agent for Frick-Reid Supply Corporation, Tulsa, Oklahoma, has been appointed manager of inventory, heading a new department to be known as the inventory department. The functions of this department will be to maintain continuous control of store, warehouse, and yard inventories to meet the demands of the trade properly.

A. F. Stadler of the purchasing department, has been appointed assistant purchasing agent.

Address Houston Nomads

Amos L. Harris, recently returned from Brazil, and F. R. Schmeider, with the Shell Oil Company of California, gave short talks at the April meeting of the Houston Chapter of Nomads at the River Oaks Country Club. Harris told of his experiences in Brazil where he was employed to install equipment and teach the Brazilians how to operate it.

Schmeider also discussed Brazil briefly, and further discussed the different practices of the various oil companies today with reference to the different types of equipment in use in various parts of the country. A sound movie was shown concerning the construction of Boulder Dam; showing each step of the construction of the dam from the beginning of the work to the day when the last power plant was installed.

Fred E. Cooper Opens Houston Branch

Fred E. Cooper, designer and manufacturer of Allis-Chalmers well-servicing units, opened a new branch plant at 1418 Franklin Street, Houston, Texas, on May 1.

This new sales and service branch carries a comprehensive line of Allis-Chalmers well-servicing units, both winch tractor and skid winch type, along with a complete line of Allis-Chalmers oil-field power engines.

The hoisting and drilling units carried in stock are those suitable for use in the Gulf Coast fields. A service and parts department also is maintained.

The new branch is managed by George Plank, who was formerly in charge of the branch at Longview.

B. E. Johnston Passes Away

B. E. JOHNSTON

B. E. "Buddy" Johnston, South American representative for Globe Oil Tools Company, Los Nietos, California, passed away at Hempstead, Texas, recently. He was on his way to Houston to take a plane for Port au Spain, his South American headquarters, when seized with a heart attack that resulted in his death. He was 43 years of age.

Buda Engine and Equipment Company to Dallas

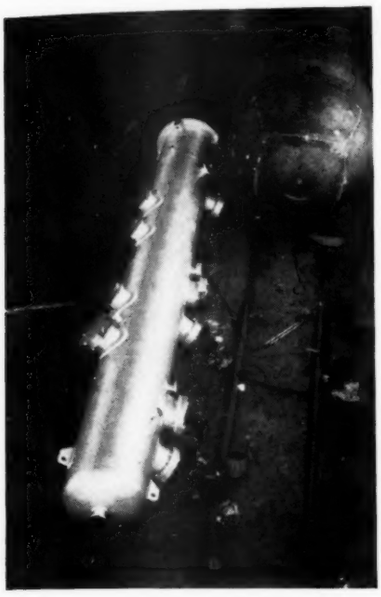
The main office and central warehouse of the Buda Engine and Equipment Company is now located at 1901 Canton Street, Dallas, Texas, having been transferred from Houston. The change was made, according to W. H. Benduhn, president, so that overnight service would be possible to any point in the territory served by the company, which includes Texas, Louisiana, and New Mexico. A branch is still maintained at Houston.

Complete New Building

Abegg and Reinhold Company, Ltd., Los Angeles, California, manufacturer of oil-well tools and commercial heat treaters, has just completed a new building 60 by 160 for heat treating. Small electric as well as large gas-heated furnaces with capacity as high as 54 in. by 60 in. by 15 ft. are being installed. In addition, a new office building will soon be under way as well as additional plant expansion.

Solution Stripping Tower

Shown here is a 4 ft. by 43 ft. 3½ in. solution stripping tower fabricated at the Birmingham, Alabama, plant of



the Chicago Bridge and Iron Company for a Bayway, New Jersey, refinery. The vessel was stress relieved.

D. B. Crawford of Parkersburg Rig and Reel Dies

D. B. Crawford, member of the board of directors of the Parkersburg Rig and Reel Company, died at his home in Parkersburg, West Virginia, on May 3. He was born in 1872 in Limavady, County Derry, Ireland, and migrated to Bradford, Pennsylvania, in 1886.

Crawford joined Bovaird and Seyfang, manufacturers of oilwell sup-

D. B. CRAWFORD

plies at Bradford, in 1889, and was continuously associated with the oilfield supply industry for the last 52 years. After serving as general salesman for this company in Pennsylvania, Ohio, and West Virginia, he went to Parkersburg in 1899 to join his brother, John M. Crawford, and organize The Parkersburg Sucker Rod Company. Later he joined The Parkersburg Rig and Reel Company as secretary and treasurer. In December, 1935, he was elected president and served until March, 1940, when he resigned and was elected to the board of directors.

Program Petroleum Division A.S.M.E.

At the semi-annual meeting of the American Society of Mechanical Engineers, June 16-19, 1941, at the Hotel Muehlebach, Kansas City, Missouri, the Petroleum Division sessions will provide up-to-date information on a wide variety of subjects—substitute motor fuels, various instrumentation problems, snythetic rubbers, oilfield equipment, and others of vital importance.

That portion of the program dealing with petroleum is shown as follows:

Monday, June 16:

"Motor Fuels and Their Substitutes," by Gustav Egloff.

"Calculation of Critical Speeds in Oil-Well Pumping Systems," by C. R. Freberg and E. N. Kemler.

Tuesday, June 17:

"The Development of Steels and Alloys for Use at Elevated Temperatures in Petroleum Refineries as Still Tubes, Furnace Supports, and Other Parts," by B. B. Morton.

"Calibration of Displacement Meters on Volatile-liquid Petroleum Fractions," by E. W. Jacobson.

Wednesday, June 18:

"Liquefaction and Regasification of Lighter Hydrocarbons," by H. C. Cooper.

"Instruments for Determining Subsurface Conditions in Oil Wells," by P. G. Exline.

Thursday, June 19:

"Measurement of Properties of Natural Hydrocarbon Systems at Reservoir Pressures and Temperatures," by Kenneth Eilerts.

"Manufacture of Synthetic Rubber From Petroleum Products," by J. H. Boyd, Jr.

"THE SAVING IS 5.85%"

"The Entirely Different Boiler and Engine Treatment"

AND WE QUOTE

"Ascribes a definite saving in fuel oil consumption to the use of your feed water treatment in our 167 hp Keeler Cross Drum Water Tube Oil Fired Boiler, operating at 185 pounds pressure.

"Deduction from engineer's log shows that during the 59 days of January and February, 1938, we used in the boiler 35,610 gallons of fuel oil, which divided by 1844 degree-days equals 19.311 gallons per degree day.

"During January and February, 1939, while using Sand-Banum, the boiler oil consumption dropped to 18.18 gallons per degree day. The saving is 1.13 gallons per degree day, or 5.85 per cent."

Regardless of water or operating conditions, type of boiler or method of firing, Sand-Banum will safely and economically remove old and prevent new scale and corrosion. Prove it to your satisfaction at our risk.

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Look for the Arm-and-Hammer
ARMSTRONG BROS.
Improved
PIPE CUTTERS

The Drop-Forged and "Combination" Pipe Cutters can be used as a 1 or 3 wheel cutter. All are improved cutters, accurately made with hardened steel pins and rollers. Thrust rods of "Saunders" type cutter are hardened at the point and bear on embedded, hardened steel block. On "Barnes Type," the thrust is taken up by drop-forged steel sections. Parts are interchangeable with other standard makes. All are Cadmium Plated.

ARMSTRONG BROS. Knife Blade Cutter Wheels cut much faster and easier, hold their keen cutting edge, for they are made of Vanadium Tool Steel, heat treated, hardened, and cadmium plated.

Write today for Catalog C-39, showing the most complete line of Pipe Tools made.

ARMSTRONG BROS. TOOL COMPANY
"The Tool Holder People"
331 North Francisco Avenue
CHICAGO, U. S. A.

In the eye of a workman, a small particle of metal can be costly... in compensation... in lost time. It's a matter of actual dollars and cents saved to provide protection with Willson Goggles. The Bullard representative is skilled at making the right goggle recommendation that will banish eye injuries once and for all from *all* your operations. Ask for Catalog 40. It contains personal safety recommendations from head to foot. E. D. Bullard Co., 275 Eighth St., San Francisco, California. B-5

Everything BULLARD in Safety

To Handle Public Relations for Roebling

Appointment of Robert T. Bowman, of Trenton, New Jersey, as director of public relations for the John A. Roebling's Sons Company, with plants

ROBERT T. BOWMAN

at Trenton and Roebling, New Jersey, and branch offices in 13 cities, has been announced by Charles G. Williams, executive vice-president and general manager of the Roebling company.

Bowman assumed his new post on May 1. He served three years as president of the New Jersey State Chamber of Commerce and retired from that position only recently.

Three Promotions by Oil Well Supply

John M. Post, manager of Oil Well Supply Company's Eastern Division since 1929, has been appointed manager, Tubular Goods Department. This

JOHN M. POST

department, at Pittsburgh, Pennsylvania, serves all "Oilwell's" sales divisions. Post joined "Oilwell" in 1905 at the Washington, Pennsylvania, store. In 1909 he transferred to Beaumont, Texas, and for the next 20 years was associated with the company's Gulf Coast and Mid-Continent activities. He first served as a district manager in 1915 at Houston and subsequently held similar positions at Shreveport and Tulsa, moving from the latter point to Oil City, Pennsylvania, in 1929 to become manager of the Eastern Division.

F. D. Smith, manager of the company's Michigan District for the last five years, has been appointed manager of the Eastern Division, which com-

F. D. SMITH

prises all domestic oil-producing areas east of the Mississippi River. Experienced as a drilling contractor, Smith joined "Oilwell" in 1928 at Owensboro, Kentucky.

A. D. Otto, manager of the company's office at Chicago since 1936, has been appointed manager of the Pittsburgh, Pennsylvania, office. Be-

A. D. OTTO

coming associated with "Oilwell" in 1924 as district sales manager at Casper, Wyoming, Otto later filled similar positions at Denver, Colorado, Calgary, Canada, and Houston, Texas. For two years preceding his transfer to Chicago as manager of that office, he was assistant manager of stores, Midwest Division, with headquarters at Dallas.

Collier New President of Crane Company

JOHN H. COLLIER

The board of directors of Crane Company, at a special meeting on May 5 elected John H. Collier as president to fill the vacancy created by the death of Charles B. Nolte on April 29.

Collier was born in Chicago in 1884, was educated at Purdue University, and joined Crane Company on leaving school in 1903. From his original position as core maker's helper 38 years ago he has progressed through various positions giving him a very intimate and thorough grasp of the company's activities. The later and more important positions in this list are: General manager, Bridgeport, Connecticut, plant, Crane Company, 1917-1929; president, Cie Crane, Paris, France, and chairman, Crane, Ltd., London, England, 1929-1933, and vice-president in charge of manufacturing, Crane Company, Chicago, 1933-1941.

Collier's first act as president was to issue the following statement:

"It is a pleasure for me to know that in taking office as president of this company, its policies are sound and well established and that the organization is at a high peak of efficiency. An outstanding feature of the Crane organization has been the fine spirit of coöperation which has existed throughout. It is my intention to continue the policies which have been in effect, and it will be my endeavor to foster that spirit of coöperation to the fullest extent."

Frauenthal Leaves Bantam, Succeeded by Nichols

A. H. Frauenthal, vice-president and general manager of the Bantam Bearings Corporation, resigned from the company, effective May 1. Frauenthal is leaving to establish a new factory in Muskegon to manufacture large special roller and ball bearings, as well as aircraft parts so badly needed for national defense.

The new factory, the name of which has not as yet been announced, will be located at Muskegon where a plant of 135,000 sq. ft. has been purchased. Employment of approximately 500 men is contemplated when full production is achieved.

Frauenthal has been with Bantam since 1930 and for the last five years has occupied the position of vice-president and general manager. Though the company is controlled by The Torrington Company of Torrington, Connecticut, Bantam has continued to operate as an independent corporation.

Previous to becoming associated with Bantam, Frauenthal occupied responsible positions with General Electric Company, Chandler Motor Car Company, and The Studebaker Corporation.

Associated with him in the new company will be H. H. Brooksieker, Cleveland, Ohio, an associate of more than 20 years, who will be vice-president in charge of manufacturing, and F. J. Donovan of Chicago, formerly well known in South Bend as treasurer of Bantam.

Frauenthal's successor, R. B. Nichols, who has been secretary and sales manager, as well as assistant to Frauenthal, has been with Bantam a number of years. He was originally associated with Bantam before it moved to South Bend in 1928. He has had long experience with the problems of the company and is thoroughly conversant with the executive details of the corporation.

For the next several months, while the new plant is being equipped, Frauenthal will act as consultant to the new Bantam management, dividing his time between South Bend and Muskegon.

Heads of Prominent Manufacturing House Die

Within a single month, two of the most prominent manufacturers in the oil industry, father and son, passed away. On April 3, 1941, Carl A. Jarecki, treasurer and assistant secretary, Jarecki Manufacturing Company, died and on April 27, 1941, his father, Alex Jarecki, president of the same company, passed away.

Alex Jarecki was the fourth member of the Jarecki family to head the firm since its founding in 1852. Carl A. Jarecki was the fourth treasurer to serve the company since its beginning.

DEFENSE AND ROTARY HOSE

The fulfillment of our National Defense Program demands that all purchases be made to the end that minimum replacements are required during the national emergency. Vital materials can be saved by the purchase of All-Steel Rotary Hose . . . one that is not affected by climatic conditions or age . . . one that costs least per foot of hole drilled . . . one that has unlimited flexibility . . . one strong, yet light in weight.

Only CHIKSAN All-Steel ROTARY HOSE Meets All These Specifications

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4" and 5" Sizes for Drilling
3" for Standby and Pressure Service
45'—50'—55'—60' Standard Lengths
Special Lengths to Order

GULF ENGINEERS, INC.—Distributors in Texas, Louisiana, Arkansas and New Mexico

WELL EQUIPMENT CO.—Distributors in Oklahoma and Kansas

CHIKSAN TOOL COMPANY
BALL BEARING SWING JOINTS for ALL PURPOSES
BREA, CALIFORNIA

ALL-STEEL ROTARY HOSE
CIRCULATING HEADS · MUD GUNS
THREE-WAY DISC BIT
STANDARD and HEAVY DUTY REAMERS

Death Takes Cooper-Bessemer President, C. B. Jahnke

C. B. JAHNKE

Charles Bernhardt Jahnke, president and general manager of The Cooper-Bessemer Corporation, died at Mercy Hospital in Mount Vernon, Ohio, on May 6 as the result of a heart attack suffered the previous Saturday.

Born at Cincinnati, Ohio, in 1889, Jahnke graduated from the University of Cincinnati and was for 21 years associated with Fairbanks, Morse and Company, having achieved the positions of chief engineer, works manager, and finally director of engineering. In 1931 he joined the International Harvester Company. Four years later he became affiliated with The Cooper-Bessemer Corporation as its chief engineer. In 1937, he became a vice-president and general manager of the corporation and, on December 27, 1940, was elected to the office of president and general manager.

Jahnke was a member of the American Society of Mechanical Engineers and Society of Automotive Engineers.

Jahnke is survived by his widow, two sons, and two daughters.

Opens New Offices

Sperry-Sun Well Surveying Company, Philadelphia, Pennsylvania, has opened three new offices in the Mid-Continent area.

To cover north Texas and southern Oklahoma an office has been opened at 2645 Lubbock Avenue, Fort Worth, Texas, with J. P. Klep as manager.

An office at Oklahoma City, Oklahoma, at 3020 N. W. 19th Street, is in charge of W. F. Krueger. He will have as his territory Oklahoma, other than the southern part, and Kansas.

L. H. Creasy will be in charge of the Lubbock, Texas, office, his address being 3207 Twentieth Street. He will cover west Texas.

Halliburton Opens Tulsa Office

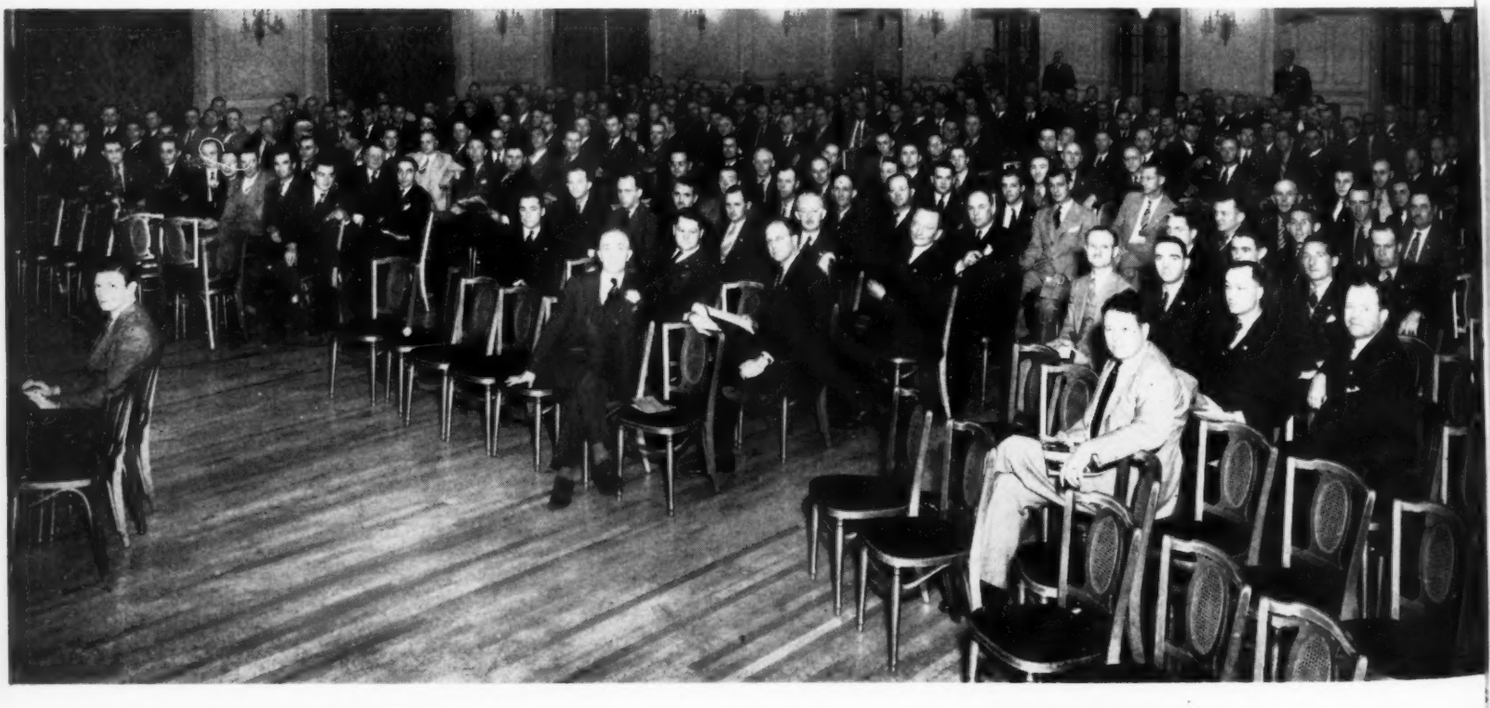
The Halliburton Oil Well Cementing Company of Duncan, Oklahoma, announces the opening of an office in the Philtower Building, Tulsa, Oklahoma.

This office is under the direction of C. P. Parsons, vice-president, who is well known throughout the oil industry for his experience and for being well informed on all activities and policies of the company. He will be in Tulsa frequently, as well as the superintendents, engineers, and geologists in the Halliburton organization who often go to Tulsa on certain problems. The new office will greatly facilitate their activities.

Charles F. Dougherty, who has had 20 years' experience in the manufacture and sale of floating equipment, casing shoes, etc., has joined the Halliburton staff as special representative, resident in Tulsa, for furthering the sale of Halliburton floating equipment. A display of Halliburton floating equipment and other products will be installed in the new office. Dougherty will also coöperate with Parsons to expedite the handling of other problems.

N.G.A.A. HOLDS RECORD MEETING AT DALLAS

Group picture taken during one of the sessions of the meeting of the Natural Gasoline Association of America, held in Dallas, Texas, recently

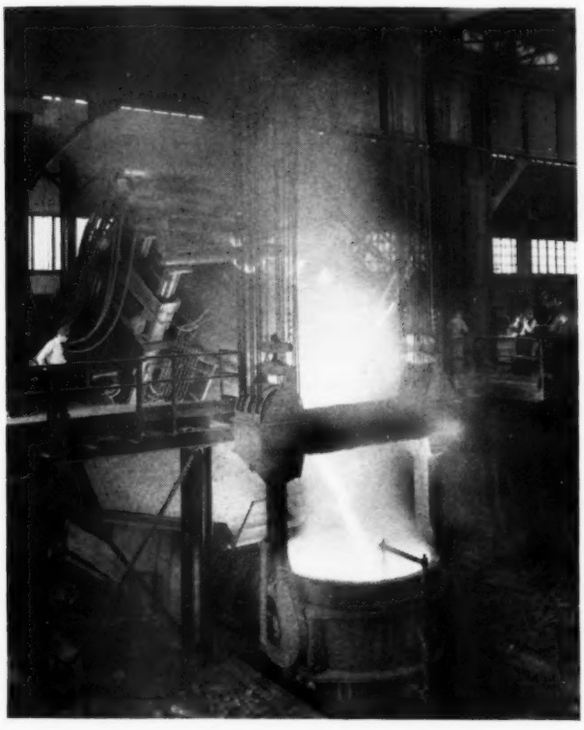


Timken Adds 65-Ton Electric Furnace

Almost on the 25th anniversary of their entrance into the steel manufacturing business, The Timken Roller Bearing Company began the operation of a new 65-ton electric furnace and stepped-up production to 360,000 tons per year.

This new furnace supplements a battery of six other units including the famed 85-ton oval shape furnace that has been in production nearly 15 years. Other furnaces in the battery include one of 60-ton capacity installed in 1938, two of 35-ton capacity that were enlarged to that size from 25 tons in 1927, and one of 20-ton capacity now being installed.

The Timken company began electric steel production in



This steel producing giant in The Timken Roller Bearing Company melt shop at Canton, Ohio, poured 80 tons on its first heat

August, 1916, with five 6-ton, hand-charged furnaces. These were all dismantled in 1927.

In addition to the electric furnace capacity, three 100-ton open hearth furnaces add 17,000 tons per month to Timken's steel output.

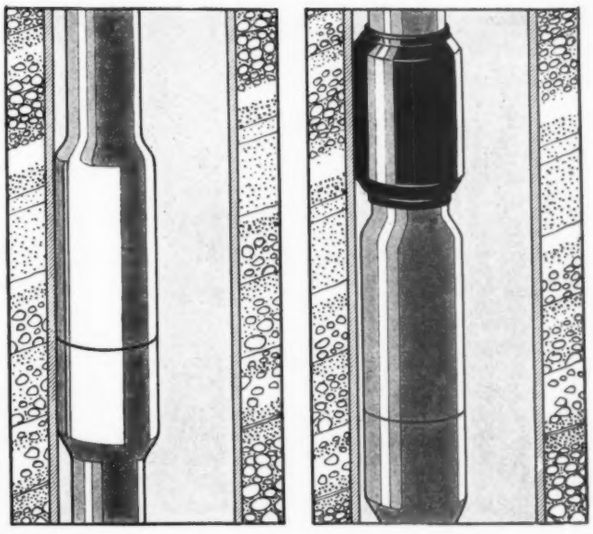
Little International Oil Show June 21-22

The Second Annual Little International Oil Show will be held in Odessa, Texas, June 21-22, 1941. Eighty exhibitors already have contracted for exhibit space.

M. L. (Dick) Atkinson, West Texas production superintendent for Phillips Petroleum Company, is general chairman.

F. H. Lindus Visits Oil Country

F. H. Lindus, manager of sales promotion, Timken Roller Bearing Company, Canton, Ohio, recently visited the Mid-Continent, Texas, and Gulf Coast areas in the interest of his company.



Unprotected *Protected*

LIP SERVICE for drill pipe

Patterson-Ballagh now makes available an improved line of Drill Pipe and Casing Protectors. Tight-gripping annular lips are provided at both ends of the Protector. By adding lips, "ringing" or grooving of drill pipe is eliminated. Swirling action of the mud takes place at the bottom of the lip on the rubber instead of in the corner of the pipe. These extended lips are molded as an integral part of the rubber. They give the Protectors more streamlining. The lips form a sealing ring which prevents mud from getting behind the Protectors. Extension of the lips at top and bottom adds approximately 15% more contact area and more grip.

Swirling action of mud does not concentrate on drill pipe. The lip of the Protector eliminates abrupt ell and the swirling occurs on the rubber which effectively resists abrasion.

Now available in popular sizes

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HOW CAN DRUM WASHING RESULTS BE IMPROVED AND COSTS REDUCED?

The RIGHT answer, according to many refineries, is by using safe, specially designed Oakite materials.

Try an Oakite material recommended for your washing equipment . . . and watch things happen! Note how THOROUGHLY AND SPEEDILY caked-on oil, grease and dirt are removed. Observe how freely solution rinses away, leaving no film or deposits to contaminate new oil. Above all, note the LOW COST of doing the job! Want details? Write today.

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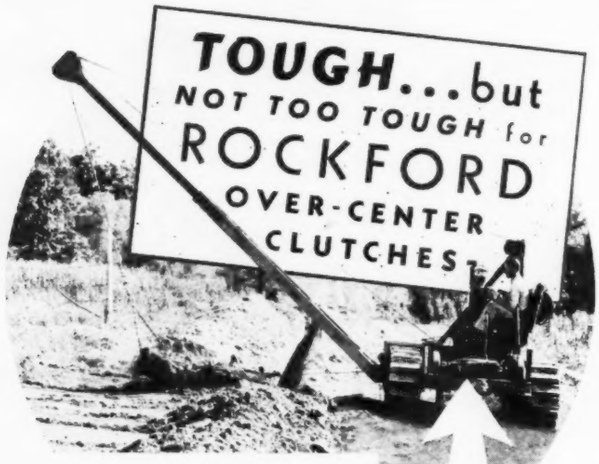

Backfilling 2 to 3 miles of trench a day in rough country is a fairly tough job . . . but not too tough for the one-man Cleveland Backfiller illustrated, or the Rockford Over-Center Clutch and Power Take-Off in its main drive.

Rockford Plate Clutches are standard equipment in leading tractors, power units, earth handling machines, road building equipment and other industrial applications. Correctly engineered, they operate easily; can take all the power handed to them and "dish it out" steadily, even on extra tough jobs. For most efficient, reliable, economical service, specify Rockford Plate Clutches in the next power-operated product you buy or build.

Rockford Power Take-Off

● Rockford Clutches are made in many sizes that meet a wide range of applications. Rockford Power Take-Offs fit S.A.E. housings, may have Over-Center or Spring-Loaded Clutches. Investigate.

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Over-Center Clutches • Spring-Loaded Clutches • Power Take-Offs

Discuss Safety Activities For Petroleum Exposition

Enlarged safety activities for the May 16 to 23, 1942, International Petroleum Exposition in Tulsa were discussed in Tulsa recently, when members of the central safety committee, announced by President W. G. Skelly, met with H. W. Boggess of the Sinclair-Prairie Oil Company, reappointed safety committee chairman. In the photograph, Boggess, seated, looks over with committee members one of the safety certificates awarded at the 1940 show.

Left to right, are: J. E. Dyer, Sun Oil Company, vice-chairman of the central committee; Hadley H. Myers, Sinclair-Prairie Oil Company, chairman of the petroleum safety council; R. S. Huffman, Oklahoma Natural Gas Company, contest committee chairman; Elmo Murphey, Mid-Continent Petroleum Corporation, program committee chairman.

Tulsa Nomads to Give Reception and Dinner

Tulsa Nomads Chapter will give a reception and dinner in honor of the national president of the board of regents, Ted Sutter, Los Angeles, and all visiting Nomads in Tulsa, from Los Angeles, Houston, and New York Chapters on Tuesday night, May 20, during the Mid-Year Meeting of the A. P. I. The affair will be in the roof garden of the Tulsa Club. The program is as follows:

Reception, 6 to 7 p.m. Dinner 7 p.m.

Address of welcome, W. G. Green, president, Tulsa Nomads.

Response, Ted Sutter, president, national board of regents.

Roll call of the Nomads.

Presentation of awards to Nomad chapters in recognition of their service during the International Petroleum Exposition, 1940, W. G. Skelly, president, I. P. E.

Acceptance, Los Angeles, E. L. Decker, past national president, board of regents.

Acceptance, Houston, Rex Hamaker, past president, Houston Chapter.

Acceptance, New York, John H. Baird, past president, New York Chapter.

Acceptance, Tulsa, Fred E. Cooper, past president, Tulsa Chapter.

Address: "Our Foreign Visitors," W. B. Way, general manager, International Petroleum Exposition.

Address: "Importance of A. P. I. Standards in Foreign Operations." (Speaker to be announced.)

There will be a special registration desk for Nomads at the Mayo Hotel, A.P.I. headquarters, from Monday, May 19 to Tuesday, May 20, noon.

Sutherland Resigns From Lone Star

T. W. SUTHERLAND L. T. POTTER

T. W. Sutherland, for 23 years superintendent of production for Lone Star Gas Company, Dallas, Texas, terminated his service with the company on May 1, according to announcement by E. F. Schmidt, vice-president and operating manager.

Sutherland entered the gas and oil industry in 1889 in Butler County, Pennsylvania, and during his service in the contracting field drilled some 500 miles of wells. He joined Lone Star in March, 1918, from his position with the United States Fuel Company of Charleston, West Virginia.

In announcing his resignation, Schmidt stated, "I am sure we will miss the association we have had with Sutherland over these many years and all agree that he is entitled to rest and recreation as a reward for faithful service. Our best wishes go with him."

All matters pertaining to the drilling of wells for Lone Star Gas Company and Lone Star Gasoline Company will be under the direct supervision of L. T. Potter, chief production engineer for the company, it is announced. Potter will have full charge of this work along with his other duties.

H. L. McNally New Sales Manager Westco Pump

Micro-Westco, Inc., Bettendorf, Iowa, has announced the appointment of H. L. McNally to position of sales manager of the Westco Pump Division. This advancement from the position of assistant sales manager resulted when Leon F. Wernentin, former sales manager, was promoted to the sales department of the Bettendorf Company, the parent organization.

H. L. McNALLY

McNally joined the company more than 16 years ago.

New! STRIKING WRENCH by PLOMB

Square striking face for hammer blows

Chrome Moly steel—oxidized blue finish

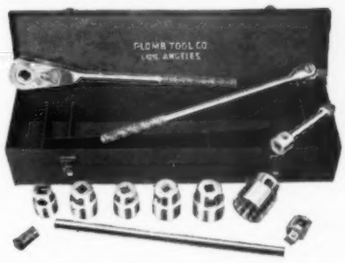
Ample offset to get into close quarters

12 point opening fits tightly, holds post

Heavy industry of all types — Diesel power plants, refineries, shipbuilding plants and many others — welcome this latest addition to the PLOMB industrial tool line. Engineered to stand up under sledge-hammer slugging where obstructions prevent use of longer-handled wrench. Finest construction — strong — fast. Box openings 13/16" to 3⅛".

INDUSTRIAL TOOL SETS

The PLOMB industrial line includes heavy duty sockets and attachments of all descriptions, designed for hard, tough service. Illustrated is set 5700 OC—ideal for jobs where ordinary tools won't stand up. Fully guaranteed. You can always trust a PLOMB tool.



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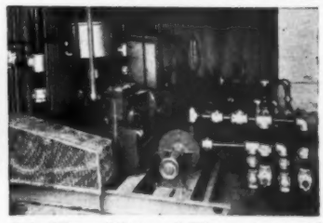

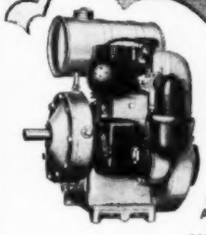

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by WISCONSIN MOTOR CORPORATION
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TRADE LITERATURE

What to Write For

BAASH-ROSS TOOL COMPANY, Los Angeles, California, announces two safety developments. One is the new drill collar slips, described in Bulletin 13-B, and the other is a multi-grip safety clamp, described in Bulletin 6-B. Both bulletins are available upon request.

BULLETIN P-104 containing information on the Bantam Quill Bearing can be had free by writing Bantam Bearings Corporation, South Bend, Indiana.

A copy of "DRILLER'S HAND BOOK," containing engineering data and helpful information for the driller and purchasing agent can be had without cost by writing the Broderick and Bascom Rope Company, St. Louis, Missouri.

Full details concerning the new BROWN CIRCULAR CHART POTENTIOMETER PYROMETER are available from The Brown Instrument Company, 4475 Wayne Avenue, Philadelphia, Pennsylvania.

J. I. CASE COMPANY, Racine, Wisconsin, announces two new models of oilfield engines, the "DE" and the "LAE." Information will be sent upon request.

Complete information on the Wiggins "Piston-Type" Balloon tank is offered to interested parties by the CHICAGO BRIDGE AND IRON COMPANY, Chicago, Illinois.

THE CLEVELAND TRENCHER COMPANY, 20100 St. Clair Avenue, Cleveland, Ohio, invites requests for information concerning their ditchers, backfillers, and pipe cranes.

THE CONTINENTAL SUPPLY COMPANY, Dallas, Texas, is sending upon request information on the Emsco Type "F" Swivel.

"ALLOY STEEL HANDBOOK" will be mailed to interested parties by Republic Steel Corporation, Alloy Steel Division, Massillon, Ohio.

THE OIL COUNTRY SPECIALTIES MANUFACTURING COMPANY, Coffeyville, Kansas, and Houston, Texas, is offering an illustrated folder on OCS Pumping Units.

THE MEDART COMPANY, 3514 DeKalb Street, St. Louis, Missouri, welcomes requests for catalogs on Medart power transmission equipment.

Information on the use of "KARBATE," a carbon or graphite base material impervious to seepage of fluids under pressure, will be sent by National Carbon Company, Inc., 30 East 42nd Street, New York, New York.

Complete details of ELECTROLOG applications are contained in a bulletin that will be sent free by Lane-Wells Company, 5610 South Soto Street, Los Angeles, California.

"Practical Information on the Use and Care of Wire Rope" will be sent complimentary by A. LESCHEN AND SONS ROPE COMPANY, 5909 Kennerly Avenue, St. Louis, Missouri.

CATALOG 34-A, published by the Penberthy Injector Company, Detroit, Michigan, discusses Penberthy drop-forged steel transparent liquid-level gauges.

Descripture literature on Pease blueprinting equipment is available from THE C. F. PEASE COMPANY, 2613 West Irving Park Road, Chicago, Illinois.

THE MARMON-HERRINGTON Pictorial News, which tells of the use of the company's vehicles in oil-field service, is available free from the Marmon-Herrington Company, Inc., Indianapolis, Indiana.

HILL, HUBBELL AND COMPANY Division of General Paint Company, Cleveland, Ohio, will send free "The Book of Pipe Protection" if the request is made on a company letterhead.

CORE LABORATORIES, INC., Santa Fe Building, Dallas Texas, has issued an interesting descriptive bulletin on its new bottom-hole sample service.

A new catalog has been prepared by THE CHAPLIN-FULTON MANUFACTURING COMPANY, 28-40 Penn Avenue, Pittsburgh, Pennsylvania, on the C-F low-pressure regulator with automatic cut-off.

CATALOG 40 contains safety recommendations; available from E. D. Bullard Company, 275 Eighth Street, San Francisco, California.

ARMSTRONG BROS. TOOL COMPANY, 331 North Francisco Avenue, Chicago, Illinois, has issued Catalog C-39 showing its complete line of tools.

Write for CATALOG-G, from Engineering Laboratories, Inc., Tulsa, Oklahoma, a condensed reference on subsurface recording instruments.

REILLY TAR AND CHEMICAL CORPORATION, Merchants Bank Building, Indianapolis, Indiana, will be glad to send literature on Reilly primer and pipe enamel.

A complete catalog of modern tools for modern industry is available free from PLOMB TOOL COMPANY, 2209 Santa Fe Avenue, Los Angeles, California.

Write for descriptive literature on the complete line of CHROME CLAD TAPES, to Lufkin Rule Company, Saginaw, Michigan.

Continental engines for industrial use are described in a bulletin available from CONTINENTAL MOTORS CORPORATION, Muskegon, Michigan.

CATALOG No. 41, issued by Globe Oil Tools Company, Los Nietos, California, has as its subject matter information concerning Globe Rock Bits. Copies of the bulletin will be sent free upon request.

MATHEY SPECIALIZED units for measuring well depths, determining fluid levels, locating obstructions, running well-shooting equipment, gas testing, and pipe beveling are contained in a catalog that is available from C. A. Mathey Machine Works, 212 South Frankfort, Tulsa, Oklahoma.

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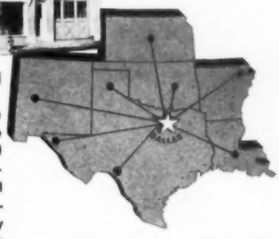

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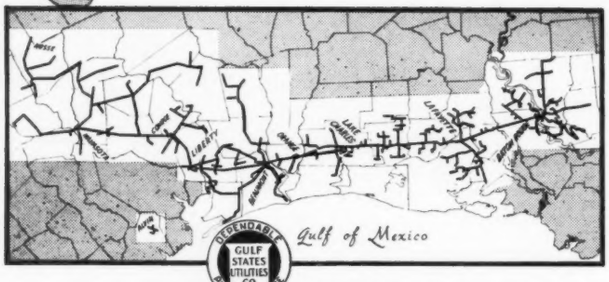

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Book Reviews

Done In Oil, by David D. Leven. Published by The Ranger Press, Inc., 347 Fifth Avenue, New York, New York. 1086 pp., illus. in colors. Price $10.00.

A truly excellent presentation of the entire oil industry, touching briefly on nearly every subject of importance in every phase of the industry.

It is well written in language that may be readily understood by the average oil man and should be a part of every company's library.

•

Fluid Mechanics, by Glen N. Cox and F. J. Germano. Published by D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, New York. 1941. 274 pp. Price, $3.00.

This volume is essentially the text of a course in the subject of fluid mechanics as presented to engineering students at Louisiana State University. These students majored in the aeronautical, electrical, mechanical, and petroleum courses, and have had only the usual preparation in mathematics, mechanics, and physics. The purpose of the course has been to better prepare the student for the problems to be encountered in industrial fields. Little space has been devoted to abstract hydrodynamical reasoning, leaving the bulk of the text available for the practical study of the behavior of fluids.

•

Elements of The Petroleum Industry. Edited by E. DeGolyer. Published by American Institute of Mining and Metallurgical Engineers, 29 West 39th St., New York, New York. Cloth bound, 21 chapters, 519 pp. Price to non-members, $5.00.

Sponsored by the Seeley W. Mudd Memorial Fund, the several chapters have been written by men outstanding in the fields of petroleum exploration, development, drilling, production, transportation, refining, marketing, accounting, economics, etc. A valuable addition to the textbook material of the industry.

•

The Time and Origin and Accumulation of Petroleum, by F. M. Van Tuyl and Ben H. Parker. Vol. 36, No. 2 *Colorado School of Mines Quarterly*, April, 1941. Published at Golden, Colorado. Price, single copy, $2.00.

An important contribution to the science of geology inasmuch as the paper represents the accumulated information resulting from a questionnaire mailed to 258 prominent workers in the subject covered. The material presented represents an analysis of the 117 contributions received at date of publication.

The pamphlet was prepared under the sponsorship of The Research Committee of The American Association of Petroleum Geologists.

•

Applied Heat Transmission, by Herman J. Stoever. Published by McGraw-Hill Book Company, Inc., New York and London. First edition, 1941. 226 pp. Price, $2.50.

This book is intended for both practicing engineers and students. Its purpose is to put into readily usable form some of the more important data on heat transmission and to describe some of the more common types of heat-transfer equipment and kinds of insulation used in industry. As indicated by the title, emphasis is placed on practical applications rather than on theory.

MEETINGS

American Institute of Chemical Engineers—May 19, 20, and 21, Chicago, Illinois.

American Petroleum Institute, 11th Mid-year Meeting—May 19, 20, 21, 22, and 23, Mayo Hotel, Tulsa, Oklahoma.

National Association of Purchasing Agents (Oil Company Buyers' Group)—May 26, 27, 28, and 29, Stevens Hotel, Chicago, Illinois.

Society of Automotive Engineers, Summer Meeting—June 1, 2, 3, 4, 5, and 6, The Greenbrier, White Sulphur Springs, West Virginia.

California Natural Gasoline Association, Monthly Meeting—June 5, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

Illinois-Indiana Petroleum Association, Ninth Annual Petroleum Conference—June 7, Robinson, Illinois.

Liquefied Petroleum Gas Association, Inc., Pacific Coast Section—June 9 and 10, Fairmont Hotel, San Francisco, California.

American Society of Mechanical Engineers, Petroleum Division, Annual Meeting—June 16, 17, 18, 19, and 20, Kansas City, Missouri.

Pennsylvania Grade Crude Oil Association, Annual Meeting—June 19 and 20, Bradford, Pennsylvania.

Kentucky Oil and Gas Association, Mid-Year Meeting—June 20 and 21, Lexington, Kentucky.

Little International Oil Show—June 21 and 22, Odessa, Texas.

American Society for Testing Materials—June 23, 24, 25, 26, and 27, 44th Annual Meeting, Palmer House, Chicago, Illinois.

American Chemical Society—September 8, 9, 10, 11, and 12, Atlantic City, New Jersey.

National Petroleum Association, Annual Meeting—September 17, 18, and 19, Hotel Traymore, Atlantic City, New Jersey.

National Lubricating Grease Institute, Annual Meeting—September 29 and 30, Stevens Hotel, Chicago, Illinois.

Texas Mid-Continent Oil and Gas Association, Annual Meeting—October 9, 10, and 11, Beaumont, Texas.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 16, 17, and 18, Dallas, Texas.

California Natural Gasoline Association—October 31, Los Angeles, California.

American Petroleum Institute, 22nd Annual Meeting—November 3, 4, 5, 6, and 7, San Francisco, California.

American Association of Petroleum Geologists—November 6 and 7, Los Angeles, California.

New Mexico Oil and Gas Association—December 3, Artesia, New Mexico.

American Institute of Electrical Engineers, Southeastern District—December 3, 4, and 5, New Orleans, Louisiana.

International Petroleum Exposition—May 16, 17, 18, 19, 20, 21, 22, and 23, 1942, Tulsa, Oklahoma.

Electrical Engineers to Meet

The American Institute of Electrical Engineers will hold its Southeastern District meeting in New Orleans on December 3, 4, 5. Headquarters will be at the St. Charles Hotel.

An interesting technical program, together with visits to many of the varied industrial plants of New Orleans, is being arranged. In addition there will be entertainment offered both for the members and their wives.

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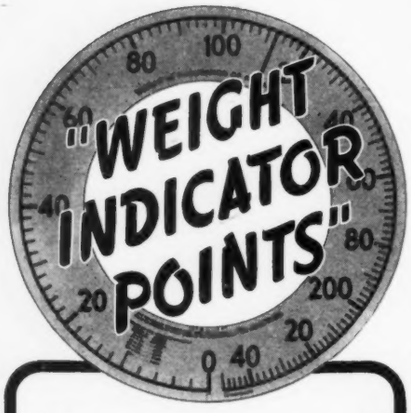

Charts obtained with Rate of Penetration Recorders clearly show the need for *accurate* drilling control instruments.

Penetration speeds vary greatly with changes in weight and in rotating speed. In fact, many times there may be a critical point in weight increase beyond which high penetration rate means *crooked* hole!

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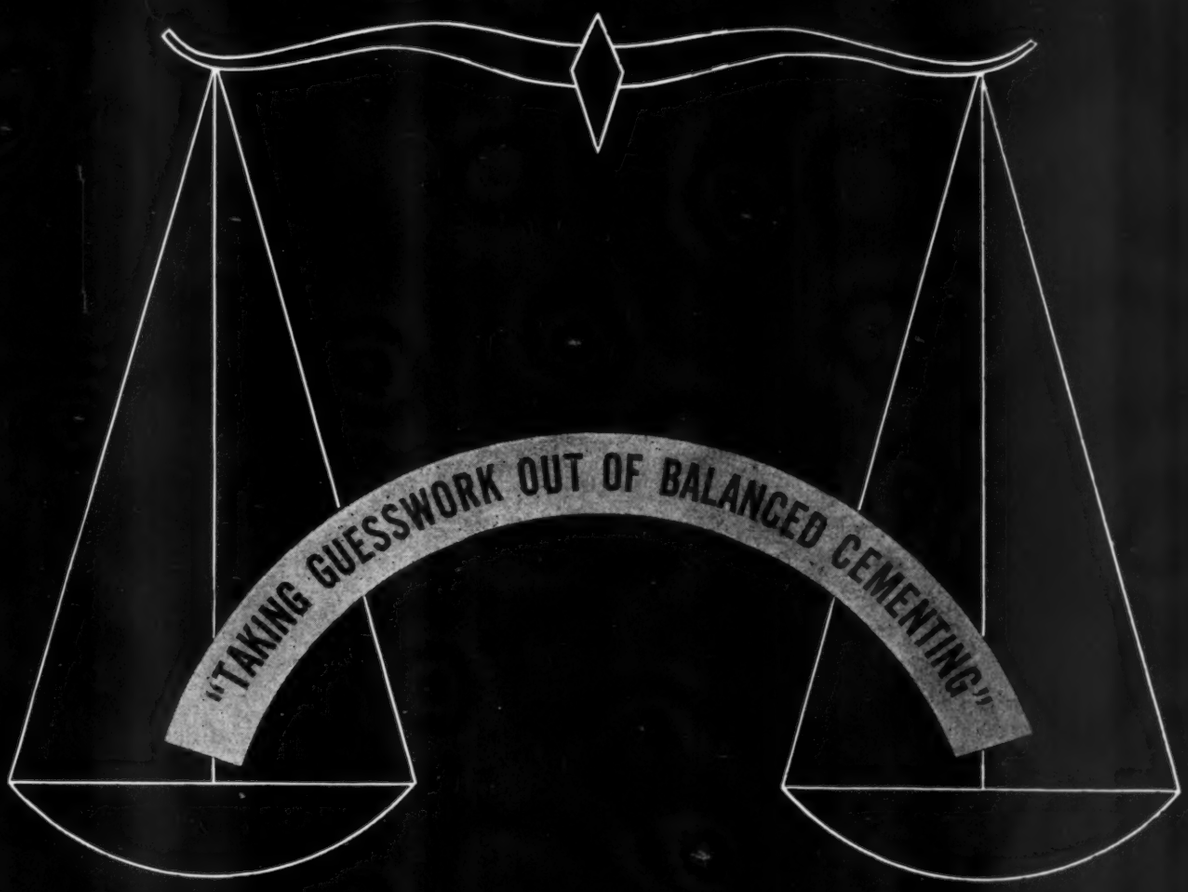

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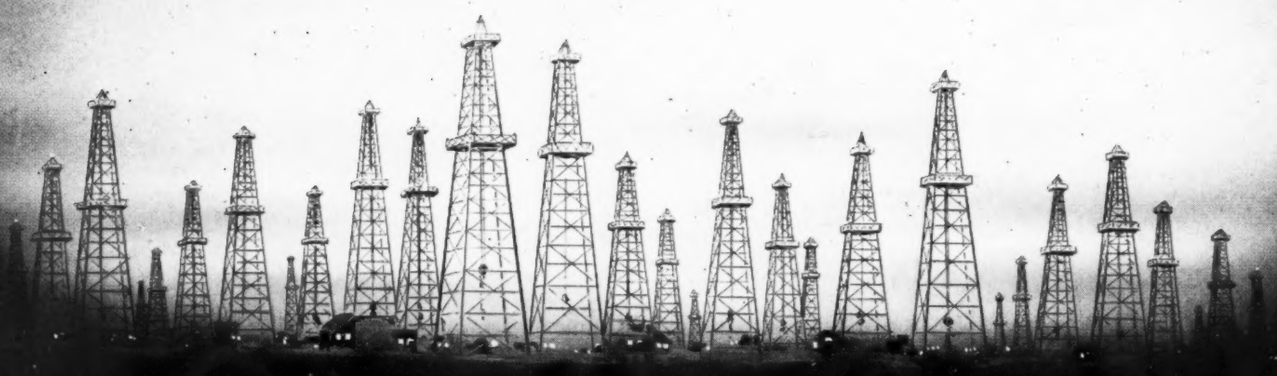

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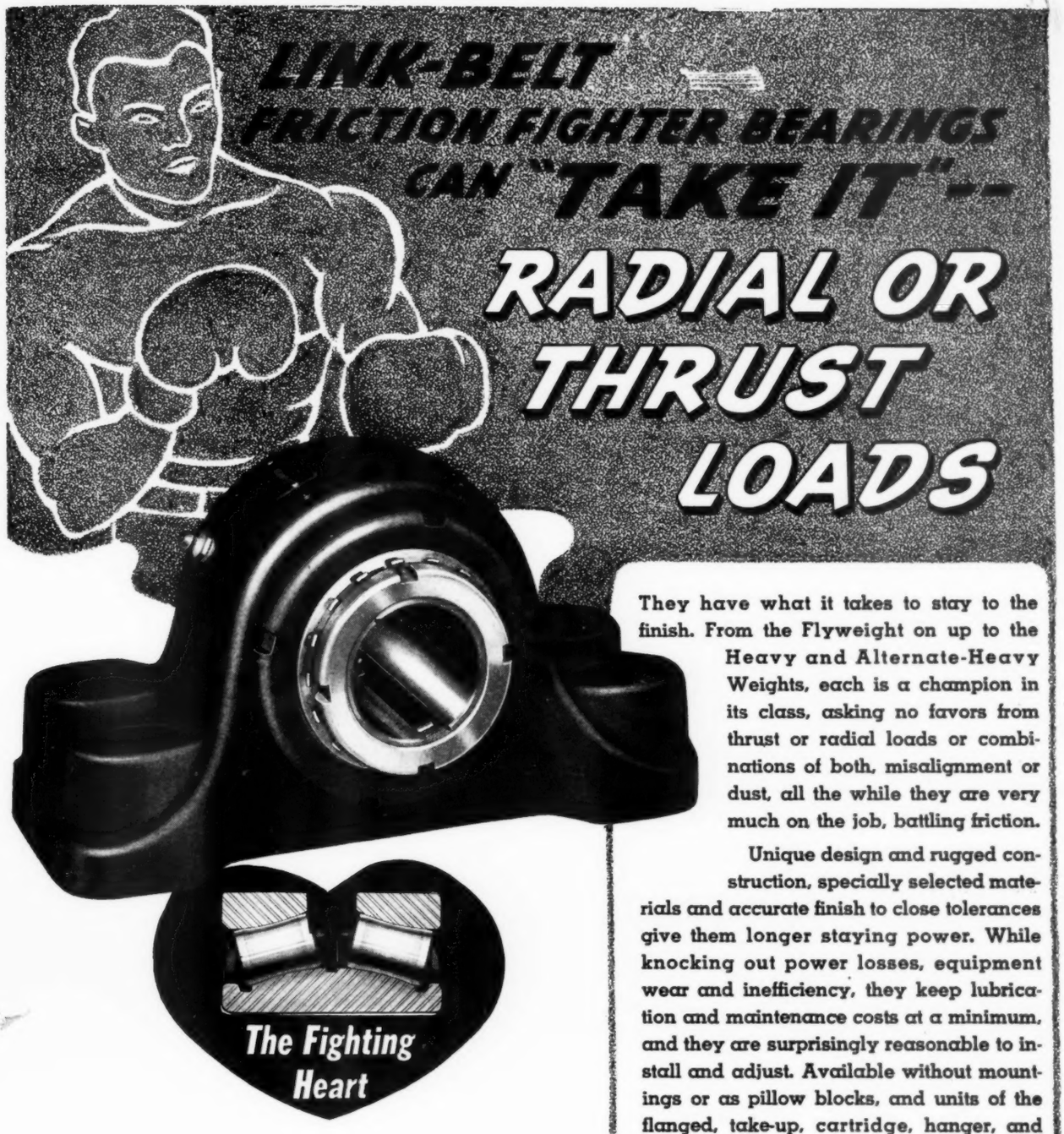

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The Petroleum Engineer, published monthly August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, seventh floor Allen Building, Dallas, Texas. Subscription price, $2.00 per year, $3.00 for 2 years, 25c a copy. Entered as second-class mail matter May 1, 1932, at the post office at Dallas, Texas, under the act of March 3, 1879.